TRANSACTIONS, AMERICAN GEOPHYSICAL UNION
VOLUME 62 NUMBER 49 DECEMBER 8, 1981

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL. 62, NO. 49, PAGES 1169-1176 DECEMBER 8, 1981

Particles and Fields—Magnetosphere

5705 Bow Shock Waves
SIMULATION OF A PERPENDICULAR BOW SHOCK
M. M. Leroy (University of Maryland, College Park, MD. 20742), C. C. Goodrich, D. Winske, C. S. Wu, and K. Papadopoulos

Simulations of a high Mach number shock with parameters typical of the earth's bow shock have been performed using a hybrid (particle ions, fluid electrons) code. The simulations reproduce the observed ion reflection and overshoots in the magnetic field and density. These features are shown to be closely associated with ion gyration. (Shock waves, numerical simulations).
Geophys. Res. Lett., Paper 1L1721

5715 Electric Fields
POLAR CAP ELECTRIC FIELD DEPENDENCE ON SOLAR WIND AND MAGNETOTAIL PARAMETERS
D. Lassmacher and J.G. Roederer (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701)

A magnetic field model with a linearly superposed uniform external field is used to study the effects of the magnetotail field intensity B_T on the relationship between the convection pattern in the polar cap and the interplanetary magnetic field (IMF). It is found that as B_T increases, the polar cap size increases, the overall electric field intensity decreases, and the dependence of the total "open" flux on the magnitude and direction of the IMF weakens. In addition, the tail field introduces significant differences between the convection patterns corresponding to "toward" and "away" IMF sectors, respectively: in the northern (southern) polar cap, features such as polar cap boundary displacements and electric field intensity gradients are more pronounced when the earth is in an "away" ("toward") sector. On the other hand, in the case of a northward-tilted IMF, sunward convection in the north (south) polar cap is extended over a larger area for a "toward" ("away") sector. Since dipole tilt was not taken into account in the model, these results should mainly apply to periods around equinox. (Electric fields, polar cap, convection).
Geophys. Res. Lett., Paper 1L1717

5720 Interaction between solar wind and magnetosphere
PLASMA ELECTRON SIGNATURE OF MAGNETIC CONNECTION TO THE EARTH'S BOW SHOCK: ISEE 3
W. C. Feldman (University of California, Los Alamos National Laboratory), R. C. Anderson, J. R. Asbridge, S. J. Bame, J. T. Gosling and R. D. Zwickl

Enhanced fluxes of low-energy electrons backstreaming from the earth's bowshock have been identified at ISEE 3. When present, these fluxes modify ambient solar wind electron velocity distributions, f(v), in characteristic ways which depend on whether ISEE 3 is near the edge of, or within the interior of the earth's electron foreshock. Near the edge, energy peaks in f(v) are observed. Such distributions should be locally unstable to electron plasma oscillations. Well within the interior of the foreshock, enhanced fluxes of electrons with energies up to the maximum detected by the Los Alamos electron analyzer (≈1 keV) are observed over the full backward hemisphere. These electrons can be modelled with an asymptotic power law distribution having index in the range $4 \lesssim P_{bs} \lesssim 6$. At intermediate energies (≈20 to 50 eV), twin angular peaks are observed centered on the magnetic field direction, B. Also observed at these times are depressions in f(v) at energies less than ≈20 eV which are centered on B. Such distributions having a perpendicular temperature greater than their parallel temperature may be locally unstable to the generation of whistler waves. Analysis of a particularly clean example of connection to the bow shock is consistent with the possibility that the observed electron fluxes emerge from the forward foot of the electron heating region within the bow shock where the electron density and temperature are larger than that of the unperturbed upstream solar wind by a factor of ≈1.2. This analysis also indicates that the electrostatic potential within the forward foot of the shock is between ≈5 and 50 volts more positive than that within plasma far upstream at ISEE 3. However these interpretations depend on the assumption of nearly scatter-free propagation, which may not hold. Using parameters derived from model fits to measured velocity distributions, we estimate ≈10^{-4} of the incident solar wind electrons are accelerated by the bow shock back into the upstream region with energies greater than 1 keV.
J. Geophys. Res., Blue, Paper 1A1654

5736 Magnetotail
EXTERNALLY DRIVEN MAGNETIC RECONNECTION VERSUS TEARING MODE INSTABILITY
T. Sato (Institute for Fusion Theory, Hiroshima University, Hiroshima 730, Japan), and A. Hasegawa

Theoretical estimate as well as numerical simulations show that while a resistive tearing mode instability saturates at a low flow velocity, an externally driven reconnection, however weakly driven, brings a new nonlinear state with strong plasma jet which squeezes out tearing mode driven magnetic islands. This result suggests that the externally induced reconnection is more than likely a candidate for explosive phenomena such as magnetospheric substorms and/or solar flares. (Magnetic reconnection, substorm, solar flares).
Geophys. Res. Lett., Paper 1L1704

5739 Magnetopause
THE MAGNETOPAUSE AS SENSED BY ENERGETIC PARTICLES, MAGNETIC FIELD, AND PLASMA MEASUREMENTS ON NOVEMBER 20, 1977
T. A. Fritz (Space Environment Laboratory, NOAA/ERL, Boulder, CO 80303), D. J. Williams, G. Paschmann, C. T. Russell, and W. H. Spjeldvik

The position of the trapping boundary for > 24 keV ions in the vicinity of the magnetopause has been determined using energetic particle three-dimensional distributions observed by ISEE 1 and 2. These observations have been compared with simultaneous plasma and magnetic field measurements for the 0130-0136 UT interval on 20 November 1977. The results show that for this interval, the magnetosheath plasma penetration depth into the magnetosphere can be limited to a distance equal to the local plasma ion gyroradius of ≲ 100 km inside the position of the trapping boundary although penetration greater than 200 km was also observed. During this time the trapping boundary was in continual, rapid motion with velocities up to ~ 90 km/sec. This motion could complicate the geometry and therefore explain the apparent depth of penetration of the magnetosheath plasma a few ion gyroradii inside the trapping region. If the trapping boundary, determined by this energetic particle sounding technique, is the last closed field line, then the observation of magnetosheath plasma a number of ion gyroradii earthward of the trapping boundary indicates that magnetosheath plasma is able to penetrate onto closed field lines. (Magnetopause, boundary layer, energetic trapped particles).
J. Geophys. Res., Blue, Paper 1A1642

5780 Wave propagation
THEORY AND COMPUTER SIMULATIONS OF MAGNETOSPHERIC VERY-LOW-FREQUENCY EMISSIONS
J. L. Vomvoridis, T. L. Crystal and J. Denavit (Department of Mechanical and Nuclear Engineering, Northwestern University, Evanston, Illinois 60201)

A theory of magnetospheric VLF emissions must account for following features: (a) the triggering of monochromatic emissions by signals of sufficient strength and duration, while the background noise and weak short signals are not amplified; and (b) the occurrence of frequency changes after the emissions have reached a sufficiently large amplitude. A nonlinear mechanism exhibiting these features, with fixed and varying frequencies, is examined analytically and by computer simulation techniques. This mechanism depends on a simultaneous propagation and amplification of wave packets along geomagnetic lines to maintain the non-uniformity ratio $R \propto \nabla B_0/B_w$ in the regime $|R| \approx 0.5$, corresponding to maximum amplification. (B_0 is the geomagnetic field and B_w is the wave magnetic field) For a constant frequency, this condition yields triggering thresholds which are related to the properties of the magnetosphere. For a varying frequency ω(t), it yields the condition $\partial\omega/\partial t \propto \omega_t^2$ for the large-amplitude portion of the risers, where $\omega_t \propto B_w^{1/2}$ denotes the trapping frequency of the wave.
J. Geophys. Res., Blue, Paper 1A1752

5780 Wave Propagation
MULTIPLY REFLECTED STANDING ALFVÉN WAVES IN THE IO TORUS: PIONEER 10 OBSERVATIONS
R.J. Walker (Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California, 90024), M.G. Kivelson

Observations from the Voyager 1 pass by the Io flux tube strongly indicate that large amplitude standing Alfvén waves are generated as Jovian plasma flows past Io. Recently Gurnett and Goertz (1981) have proposed that this Io generated standing Alfvén wave system extends an appreciable way around the Io L-shell. In this paper, we present observations of magnetic perturbations found in the Pioneer 10 record as it crossed the Io L-shell. The field perturbations are qualitatively consistent with the passage of the spacecraft through a standing Alfvén wave pattern. The observations imply an Alfvén Mach number of 0.03, which is 1/3 of the value inferred from Voyager 1 observations. This implies a lower plasma density at the time of the Pioneer 10 flyby. (Standing Alfvén waves, Io torus, Jupiter).
Geophys. Res. Lett., Paper 1L1705

5799 General
LOWER HYBRID ACCELERATION AND ION EVOLUTION IN THE SUPRAURORAL REGION
Tom Chang (Center for Space Research, Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139), and Bruno Coppi

It is shown that ions can be accelerated perpendicularly to the magnetic field lines by resonant interactions with lower hybrid modes. Taking into account the effects of the magnetic field inhomogeneity, we demonstrate that the accelerated portion of the ions of ionospheric origin in the suprauroral region of the magnetosphere can evolve into conic distributions and propagate upwards along the field lines. Thus, these ions can reach the region where they can be strongly energized along the field lines by the electrostatic shocks. We can argue that the ion distribution resulting from the combination of these accelerated ions with the background ions can depart significantly from a thermal distribution and lead to the excitation of electrostatic ion cyclotron modes.
Geophys. Res. Lett., Paper 1L1708

PHOTOCHEMISTRY IN PLANETARY ATMOSPHERES

J. S. Levine
NASA-Langley Research Center, Hampton, Virginia

T. E. Graedel
Bell Laboratories, Murray Hill, New Jersey

Theoretical studies of the photochemistry of planetary atmospheres (including those of the ancient and modern earth) are based on physical and chemical premises common to all. Widely varying paths of evolutionary history, atmospheric processes, solar fluxes, and temperature have produced vastly different atmospheres, however. Some of these similarities and differences are described in this paper, which is based in part on invited presentations at the Fall 1980 AGU Meeting.

Introduction

Ozone is a constituent of earth's atmosphere; it is also found in the atmosphere of Mars. Sulfur dioxide is a constituent of the atmosphere of Venus; it is also found in the atmosphere of Io. Methane may have been a constituent of the earth's ancient atmosphere; it is found today in the atmospheres of Titan, Jupiter, and Saturn. Can chemists explain these similarities between systems so different in their physical properties?

Over the last decade and a half, considerable progress has been made in the study of the chemistry of the atmospheres of the planets and their larger satellites (some of the characteristics of which are listed in Table 1). Much of the early research (in the middle and late sixties) was stimulated by NASA's program of exploration of Mars and Venus by the Mariner spacecraft. These early studies were largely concerned with the photochemistry of the carbon dioxide (CO_2) atmospheres of Mars and Venus and of the stability of these predominantly CO_2 atmospheres against photolysis by solar ultraviolet radiation.

In the 1970's, there was a sharp increase in public concern over issues related to the chemistry of the earth's atmosphere, particularly the impact of anthropogenic activities on the composition of the global atmosphere and on climate. Although for several decades the chemistry of urban air pollution had been a clearly recognized local problem, only recently have the effects of anthropogenic activities on the global atmosphere been recognized as potentially significant. National and international concern has centered on the possible inadvertent depletion of stratospheric ozone (O_3), which protects the surface of earth from potentially harmful solar ultraviolet (200—300 nm) radiation. Atmospheric chemists have studied the possible depletion of stratospheric O_3 by a variety of anthropogenic activities: nitrogen oxides (NO_x = NO + NO_2) produced by high altitude supersonic transports, chlorofluorocarbons released from a variety of sources, and enhanced levels of nitrous oxide (N_2O) resulting from increased global use of nitrogen fertilizers.

Atmospheric chemists have also studied the effects of anthropogenic activities on the quality of the air that we breathe, on vegetation, and on the chemistry of natural bodies of water. These studies have included formation and deposition of acid precipitation and the possible effect of enhanced levels of CO_2 resulting from increased burning of fossil fuels (particularly coal) on the earth's climate.

Several anthropogenic activities have been identified as significant sources of various gases to the regional and global troposphere, including CO_2 and sulfur dioxide (SO_2) from fossil fuel burning, NO_x and carbon monoxide (CO) from internal combustion engines, and ammonia (NH_3) resulting from coal conversion and combustion and from the volatilization of nitrogen-containing agricultural fertilizer. Several of these anthropogenic gases initiate chemical reactions that lead to the production of other gases and atmospheric aerosols. Near the ground, CO is involved in a complex series of chemical reactions that leads to the formation of O_3, which is both a pollutant and an irritant. Anthropogenic NO_x and SO_2 lead to the chemical production of nitric acid (HNO_3) and sulfuric acid (H_2SO_4), respectively, the two dominant acids in rain and snow. Anthropogenic NH_3, NO_x, and SO_2 lead to the chemical production of atmospheric aerosols (i.e., ammonium nitrates and ammonium sulfates). These aerosols affect visibility and may alter the earth's radiation balance by perturbing the natural ultraviolet, visible, and infrared energy fluxes. During the coming decades, energy generation and industrial and agricultural activities may increase at a very rapid rate, and atmospheric chemists are attempting to predict the effects of such growth on the chemistry of the future atmosphere.

Coincident with these efforts to predict the future, others are looking back in time to study the origin and evolution of the earth's atmosphere. Atmospheric chemists are studying the chemical composition of the early atmosphere and how that composition varied over geological time. They are attempting to deduce the atmospheric conditions on the early earth that were involved in the chemical evolution of the complex molecules (the building blocks of life) and subsequently to biological evolution on our planet.

During the last decade, planetary exploration flourished, with sophisticated interplanetary spacecraft probing the atmospheres of Venus, Mars, Jupiter, Saturn, and the satellites of Jupiter and Saturn. The Mariner, Viking, Pioneer, and Voyager spacecraft transmitted new and exciting information about these planets and provided atmospheric chemists with an unparalleled opportunity to study the chemistry of their atmospheres. Thus, it is not surprising that the last decade has been one of tremendous progress in our understanding of the chemistry of the earth's atmosphere — past, present and future — and of the atmospheres of the other planets. Against this background the American Geophysical Union organized a day long symposium on 'The Photochemistry of Planetary Atmospheres' during the Fall 1980 meeting in San Francisco. In a series of invited papers, 14 atmospheric chemists reviewed the recent progress in their areas and identified the problems for future research. This report is a summary of our current knowledge of planetary photochemistry, based in part on the presentations of the symposium.

TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

The Weekly Newspaper of Geophysics

Send double-spaced manuscripts (four copies) to *Eos*, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

Editor: A. F. Spilhaus, Jr.; **Associate Editors:** Claude J. Allegre, Peter M. Bell, Kevin C. Burke, Arnold L. Gordon, Kristina Katsaros, Gerard Lachapelle, Christopher T. Russell, Richard A. Smith, Sean C. Solomon, Carl Kisslinger; **News Writer:** Barbara T. Richman; **Editor's Assistant:** Sandra R. Marks; **Eos Production Staff:** Patricia Bangert, Margaret W. Conelley, Eric Garrison, James Hebblethwaite, Dae Sung Kim, Michael Schwartz.

Officers of the Union

J. Tuzo Wilson, President; James A. Van Allen, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

Eos, Transactions, American Geophysical Union (ISSN 0096-3941) is published weekly by the American Geophysical Union from 2000 Florida Avenue, N.W., Washington, D. C. 20009. Subscription available on request. This issue $5.00. Second-class postage paid at Washington, D. C., and at additional mailing offices.

Cover. The 7-m antenna and 0.6-m secondary aperture used at Bell Laboratories, Crawford Hill, New Jersey, for centimeter wave space-earth propagation experiments. These experiments measured radio signal amplitude scintillation caused by turbulence in clouds and depolarization and attenuation caused by solid and liquid hydrometeors. Signal sources were 19 and 28 GHz beacons on geosynchronous COMSTAR satellites. The 7-m antenna is also used for millimeter wave radio astronomy. (From D. C. Cox et al., Observations of cloud-produced amplitude scintillation on 19- and 28-GHz earth-space paths, *Radio Science, 16*(5), 885–907, 1981.)

VARIATION OF O_3 PROFILE WITH LEVEL OF O_2

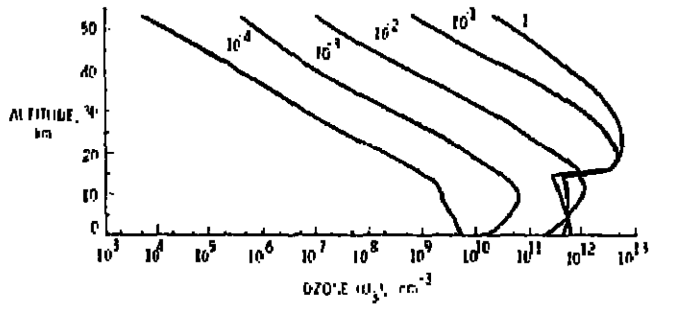


Fig. 1. Theoretical calculations of ozone profiles as a function of molecular oxygen level (in terms of present atmospheric level) in the earth's ancient atmosphere. (J. S. Levine, T. R. Augustsson, R. E. Boughner, M. Natarajan, and L. J. Sacks, in *Comets and the Origin of Life*, edited by C. Ponnamperuma, D. Reidel, Hingham, Mass., 1981.)

The Earth's Ancient Atmosphere

James C. G. Walker (University of Michigan) began the session with a paper entitled 'Chemical Evolution of the Atmosphere.' From the standpoint of the atmospheric chemist, the early earth is like another planet, with distinct bulk atmospheric composition, solar luminosity, rotation rate, and tectonic properties. Data on the properties of the paleoatmosphere have been preserved, albeit imperfectly, in the sedimentary rock record.

The rock record begins 3.8 billion years (b.y.) ago with highly metamorphosed sediments at Isua in west Greenland. These rocks indicate an early atmosphere containing H_2O and CO_2 and without abundant methane (CH_4). A diverse biota existed by 3.5 b.y. ago, as demonstrated by remains discovered in the Warrawoona Rock Group of western Australia. The continued presence of life sets constraints upon the temperature and composition of the paleoatmosphere.

The bulk composition of the atmosphere — paleo and present — depends on complex interactions between atmosphere, ocean, crust, and biota. Interpretation of the rock record is providing an increasingly clear picture of how these interactions may have been different on the early earth. Of importance is a gradual increase with time of the area of dry land. At about 2.5 b.y. ago, there was a relatively rapid increase in the area of continental crust.

Oceanic composition was dominated by interaction with the mantle of the early earth. It was a reducing medium, probably saturated with ferrous iron. The continental influence on oceanic composition did not become apparent until the end of the Archean, 2.5 b.y. ago. Theoretical studies of the rates of tidal energy dissipation indicate that the day was about 15 hours long for the first few billion years of earth history.

The geologic record of climatically sensitive sedimentary rocks suggests a climate not very different from that of the last few hundred million years of earth history. This information, coupled with increasing solar luminosity, can be interpreted to provide estimates of the partial pressure of CO_2 in the ancient atmosphere (these estimates are a few hundred times the present CO_2 value). The rock record concerning the reduction/oxidation state of the atmosphere and hydrosphere is particularly rich. Oxidized minerals first began to form about 2.3 b.y. ago. By about 1.7 b.y. ago both the atmosphere and hydrosphere contained enough oxygen (O_2) to support aerobic life.

Joel S. Levine (NASA Langley Research Center) reviewed the 'Photochemistry of the Paleoatmo-

TABLE 1
Physical Properties of Planetary Atmospheres

		Radius (km)	Solar Dist. (Au)	T (°k)	P (atm)	Main Atmospheric Gases
Earth	(Ancient)	6378	1.0	160-300	1.00-1.26	CO_2, N_2, CO (CH_4, PN_3, H_2)
Earth	(Troposphere)	6378	1.0	270-300	0.1-1	N_2, O_2 (CO_2, H_2)
Earth	(Stratosphere)	6392	1.0	210-270	.001-.1	N_2, O_2 (CO_2, O_3)
Earth	(Mesosphere)	6378	1.0	160-270	10^{-6}—10^{-3}	N_2, O_2 (CO_2)
Venus		6200	0.7	800-900	10^{-1} - 1	CO_2 (N_2)
Mars		3400	1.5	140-250	10^{-6}—6×10^{-3}	CO_2 (N_2)
Jupiter		71400	5.2	110-180	.001-2	H_2, He
Saturn		60400	9.5	90-150	.001-2	H_2, He
Uranus		23800	19.2	60-150	.001-5	H_2, CH_4
Neptune		22300	30.0	50-150	.001-10	H_2
Pluto		3000	29.8	50-80	10^{-4}—5×10^{-3}	CH_4
Titan		2560	9.5	~90	~1.5	N_2 (CH_4)
Triton		2500	30.0	~80	~10^{-4}	H_2, N_2, Ar, CH_4

sphere.' As was previously noted, the chemical composition and evolution of the paleoatmosphere were controlled by a strong coupling between the atmosphere, the oceans, the solid earth, and, eventually, the biosphere. The composition was also modified by various atmospheric processes, including photochemical reactions (initiated by the action of solar ultraviolet radiation, which was considerably more intense in the O_2-deficient paleoatmosphere), chemical reactions, lightning, rainout, and the exospheric escape of light atmospheric gases. Photochemical studies of the paleoatmosphere can be divided into three main areas of research: (1) the photochemistry and stability of the early anaerobic atmosphere, (2) the chemical transition to an oxidizing atmosphere, and (3) the origin and evolution of atmospheric O_3, with the accompanying shielding of the earth's surface from lethal solar ultraviolet radiation.

Since the early laboratory experiments on chemical evolution, in which complex organic molecules (the precursors of living systems) were synthesized in mixtures of NH_3 and CH_4 exposed to ultraviolet radiation or laboratory electric discharges, it became fashionable to believe that the prebiological primitive atmosphere contained large amounts of NH_3 and CH_4. However, photochemical calculations indicate that such an early prebiological atmosphere would have been highly unstable against photolysis by solar ultraviolet radiation and, hence, would have been very short lived, on a geological time scale, if it ever existed at all. In addition, there is no geological or geochemical evidence in the rock record to support such a highly reducing early atmosphere. A more mildly reducing atmosphere of N_2, CO_2, CO, and H_2 (resulting from volcanic outgassing) is now favored by photochemical, geological, and geochemical considerations. Complex organic molecules have been synthesized in such laboratory mixtures. Recent photochemical calculations also indicate that large amounts of nitrates (formed by lightning) and formaldehyde (formed by atmospheric reactions) could have been transported to the early ocean by precipitation in the O_2-deficient paleoatmosphere.

The transition from a reducing paleoatmosphere to an oxidizing atmosphere resulted from the build up of atmospheric O_2. Photochemical calculations indicate that the photolysis of H_2O, with the accompanying exospheric escape of H, was probably not a significant source of O_2 over geological time. The inefficient exospheric escape of H (comparable to today's value) and the volcanic outgassing of H_2 lead to efficient reformation of H_2O, at the expense of O_2 build up. In the prebiological paleoatmosphere, O_2 was not evenly mixed with altitude, but had a concentration of about 10^{-12} present atmospheric level (P.A.L.) or less at the surface, and a maximum concentration of about 10^{-8} P.A.L. at about 40 km. It appears that photosynthetic activity was the major source of atmospheric O_2, although there is considerable uncertainty as to the exact chronology for the build up of atmospheric O_2 over geological time.

Recently, a great deal of research has centered on the origin and evolution of O_3, which was strongly coupled to the build up of O_2 (see Figure 1). The evolution of O_3 and the variation of solar ultraviolet radiation reaching the surface of the earth over geological time (which is controlled by O_3) may have had very important implications for the origin and evolution of life on our planet. Studies on the evolution of O_3 have been based on detailed one-dimensional tropospheric/stratospheric photochemical models that include the chemistry of the oxygen, nitrogen, hydrogen, carbon, and chlorine gases. These studies have shed new light on the photochemistry of the paleoatmosphere (for O_2 levels of 10^{-4} P.A.L. to the present). In the O_2-deficient paleoatmosphere, the enhanced level of solar ultraviolet radiation rendered photolytic destruction the primary loss mechanism for N_2O, N_2, and O being the products. (In the present atmosphere, N_2O is largely oxidized to NO_x, thus becoming involved in the stratospheric ozone cycle.) The enhanced levels of solar ultraviolet radiation in the O_2-deficient paleoatmosphere also resulted in the efficient production of OH via the photolysis of H_2O resulting in surface and atmospheric levels of OH several orders of magnitude greater than in the present atmosphere. The sensitivity of paleoatmospheric O_3 to varying values for solar luminosity, atmospheric temperature, vertical eddy transport, and trace atmospheric gases have been assessed in these studies.

The Earth's Present Atmosphere

T. E. Graedel (Bell Laboratories) discussed the 'Photochemistry of the Regional Troposphere.' The chemistry of the regional troposphere (a regime defined as encompassing distance scales of the order of 10—1000 km) is intertwined with, but not dominated by, meteorological motions and local emission sources. The time scales of the air motions prescribe the chemical lifetimes of interest, ~1 hour to 5 days, and thus define the species whose chemistry must be studied. These include ammonia, the oxides of nitrogen, the sulfur-containing compounds hydrogen sulfide (H_2S) and sulfur dioxide (SO_2), and many alkenes, terpenes, aromatics, and aldehydes.

The following are among the regional tropospheric problems of current interest:

1. Downwind Effect. The concentrations of a variety of photochemical products are known to be higher downwind than in the vicinity of the precursor emissions. This effect, an example of which is shown in Figure 3, is qualitatively understandable as a consequence of the interplay between the chemical reaction times of the emittents and the wind velocity. Recent model studies show promise of being able to reproduce this effect quantitatively as well. Detailed measurements are needed to guide further model development.

2. Fate of Terpenes. Terpenes are emitted from vegetation in large, though uncertain, amounts. It has been proposed that they are largely converted to aerosols in the atmosphere, forming the 'blue haze' often seen over forests. Alternatively, it has been proposed that they are chemically fragmented into small molecules, thus constituting a significant global source of CO and H_2. The emission fluxes and the fate of the terpenes remain unresolved.

3. Plume Interactions. On the regional scale, emission plumes from cities and from isolated industrial complexes are often brought into contact by meteorological motions, with apparently dramatic chemical consequences in some cases. Efforts to model these processes by combining detailed descriptions of organic and inorganic photochemistry and of boundary layer meteorology are in their infancy.

4. Aerosol Nucleation and Growth. Chemical evidence from airborne particulate matter implies that a rich chemistry occurs on particles as a result of their nucleation and growth from reactive gas molecules. Our understanding of these processes is poor and appears limited at present by theoretical uncertainties more than by lack of data, although the latter are surely scanty.

5. Acid Rain. It seems clear that oxides of sulfur and nitrogen emitted in the gas phase are responsible for the increasing acidity of precipitation in northern Europe, northeast United States, and other areas. The rates at which the gas-to-drop transitions occur, and, in fact, the mechanisms of that occurrence, are poorly known. A marriage of atmospheric chemistry, aerosol physics, and cloud physics may be required to reduce the problem to quantitative understanding.

The regional troposphere is probably the most chemically diverse of any of the planetary atmospheric regimes. Perhaps more than any other regime, it must blend emissions, meteorology, and chemistry to analyze properly the processes that occur. Its study is an example of the interdisciplinary requirements of modern atmospheric and planetary science.

William L. Chameides (Georgia Institute of Technology) reviewed the 'Photochemistry of The Global Troposphere.' Key elements of the tropospheric photochemical system are (1) the production of the free radical OH in the presence of solar radiation and (2) the emission of reduced gases from the earth's surface. Tropospheric OH triggers the oxidation of many of the reduced gases generated at the earth's surface and ultimately causes their transformation into chemical forms that are readily removed from the atmosphere by rainout and other heterogeneous processes. Thus, tropospheric photochemistry supplies the atmospheric link in the biogeochemical cycling of elements such as C, N, and S. In addition, this chemical system can perturb life systems by influencing important environmental parameters such as surface temperature (via the atmospheric 'Greenhouse Effect'), the acidity of rainfall (via the production of and incorporation in precipitation of H_2SO_4 and HNO_3), and the concentrations of potentially toxic species.

Forum

Trend Toward Multiple Authors in Research Publications: Failure of the Universities to Support Research

In a previous letter to this column [*Fraser-Smith*, 1979] one of us drew attention to the marked decline since 1950 in the percentage of single-author papers in the *Journal of Geophysical Research, 1, Space Physics* (JGR 1) and the commensurate increase in the percentage of articles by three or more authors. The decline in single authors is certainly not confined to JGR 1, as is shown by more recent work (according to the Institute for Scientific Information, which indexes 2800 journals, the average number of authors per paper rose from 1.67 to 2.58 between 1960 and 1980) [*Broad*, 1981], so it seems clear that there is a widespread change taking place in the way scientists report the results of their research. It is perhaps important for us to point out that this is not an academic change; it is taking place right now, and most readers of this column are likely to be affected by it.

There is undoubtedly an element of fashion involved in the decline of single authors, and it may well be that what we are all experiencing individually as scientists is a subtle process of rhinocerization, as described in the play by *Ionesco* [1960]. However, it would be unusual for a fashion to persist for 30 years or more unless other more substantive factors were involved. The question is, what are these factors?

It would be easy to blame the federal government for the change that is occurring in our reporting habits [see *Price*, 1981] since funding of research by federal agencies first became significant in the 1950's and, as we all know, it has grown remarkably since. However, an extension of the earlier work on authors, as suggested to us by C. T. Russell, indicates that the changes in the numbers of authors per article are not linked directly to the growth in federal funding. In fact, we will argue that a more important reason for the decline in single authors is a lack of support by our universities.

Following the suggestion by Russell, we reanalyzed our multiple-author data for JGR 1 according to the acknowledged sources of support for the work. Needless to say, our new data are less quantitative than before, but the trends, as illustrated in the figure, are probably accurate. Shown in the figure are the variations since 1950 in the percentages of papers acknowledging NASA, NSF, or ONR support (these are the three most frequently acknowledged agencies in JGR 1), or no support. Note that it is the percentages of papers in each category that are plotted (one, two, three or more authors), and thus the trends in the number of authors per article previously discussed should not be evident. Clearly, the percentage of papers with no acknowledgement of support has decreased substantially in every author category since 1950, with the most marked decrease occurring in the papers by either one or two authors. Sadly, the percentage of papers acknowledging support from ONR, the first of the U.S. government research funding agencies, has also declined. However, NASA and NSF support has increased substantially and has more than made up for the decline in ONR support. The most interesting feature of the increase since 1960 in the percentage of papers acknowledging support from NASA and NSF is that it takes place in all author categories. In other words, the advent of large-scale federal funding cannot be held directly responsible for the precipitous decline in single-authored papers since 1950.

A possible clue to another cause of the decline is obtained by comparing the acknowledgements in single-authored papers for 1960 and 1980. It was rather common in 1960 for single authors affiliated with U.S. universities to omit acknowledgement of a source of funds for their research (29% of the relevant authors fall into this category; the percentage is even greater in earlier years), whereas in 1980, essentially all such authors acknowledge a source of funds outside their university (only 3% fail to acknowledge support). This result is open to a variety of interpretations, but it appears that an entire class of researchers may have disappeared in the interval 1960–1980: the university researcher, usually a tenured professor, supported solely by university funds. If this is the case, a prime source of diversity and originality in research has undoubtedly been lost. One has only to read the recent comments by *Willenbrock* [1981] on the decline in U.S. technological leadership to realize that this loss has implications beyond the mere authorship of scientific papers.

We will not dwell on the advantages of U.S. government research contracts and grants to the universities or on the pressures that are exerted on university faculty and staff to bring in federal funds for research. Instead, we wish to point out that there is an alternative but neglected way to support research at universities. Once again the clue is provided by the acknowledgement sections of the papers we have analyzed. On a very few occasions, support from research funds administered by a university is acknowledged [e.g., *Schwind et al.*, 1960; *Rankin and Kurtz*, 1970]. We might ask why these acknowledgements are so few. It appears that the ready availability of federal funds for research in the past has blinded university research administrations to the advantages of a general research fund, established and increased by gifts and bequests, whose income is used solely to fund internal (or even external) research proposals. Some of the strings normally attached to federal funds, long bemoaned by these administrations, can be avoided, and a wider range of research can be undertaken, in keeping with the particular objectives of the universities. Most important, the disturbing possibility that the federal funds for particular programs of research can be eliminated by the efforts of small groups of congressmen, or even a single U.S. senator, as appears to be happening now in the case of the NASA-funded Search for Extraterrestrial Intelligence (SETI) program, can be more easily avoided.

It might be argued that U.S. universities cannot afford to support research out of their own funds. We disagree. Large sums are raised each year from alumni, companies, and other sources, particularly at what are termed the 'major research universities' (i.e., universities that have been particularly successful at soliciting federal research funds), and even a small diversion of these funds each year into a university research fund (specifically earmarked for research) could soon produce significant income.

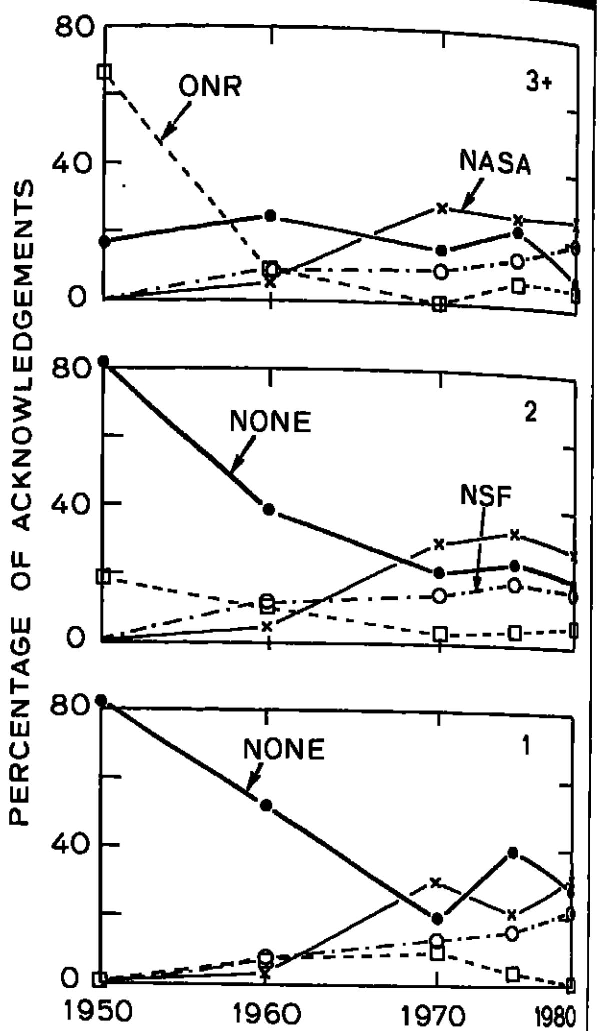


Fig. 1. Variation since 1950 in the acknowledgements of NASA, NSF, and ONR financial support in papers with one (bottom panel), two (middle), and three or more (3+; top panel) authors published in the *Journal of Geophysical Research*. Also shown is the variation in the proportion of papers with no acknowledgement of financial support. The percentages that are plotted apply to each author category.

References

Broad, W. J., The publishing game: Getting more for less, *Science, 211*, 1137, 1981.

Fraser-Smith, A. C., Trend toward multiple authors in research publications: Mutual funding of scientists, *Eos Trans. AGU, 60*, 700, 1979.

Ionesco, E., The rhinoceros, in *Rhinoceros and Other Plays*, p. 141, Grove Press, New York, 1960.

Price, D., de S., Multiple authorship, *Science, 212*, 986, 1981.

Rankin, D., and R. Kurtz, Statistical study of micropulsation occurrences, *J. Geophys. Res., 75*, 5444, 1970.

Schwind, J. J., J. W. Berg, and K. L. Cook, *PS* converted waves from large explosions, *J. Geophys. Res., 65*, 3817, 1960.

Willenbrock, F. K., United States and technological preeminence, *Science, 213*, 1319, 1981.

A. C. Fraser-Smith
Z. R. Hitchcock
Radioscience Laboratory
Stanford University

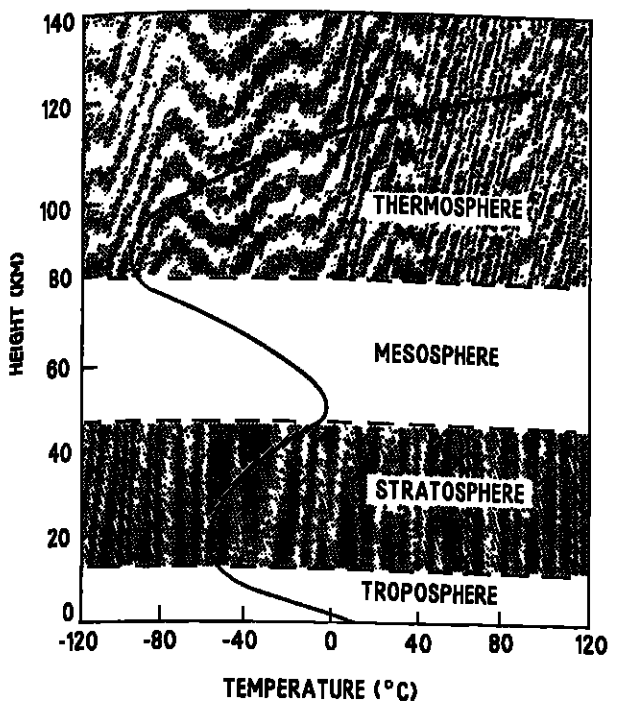


Fig. 2. The four principal layers of the earth's present atmosphere. The boundaries between the layers fluctuate somewhat with time and with geographical location.

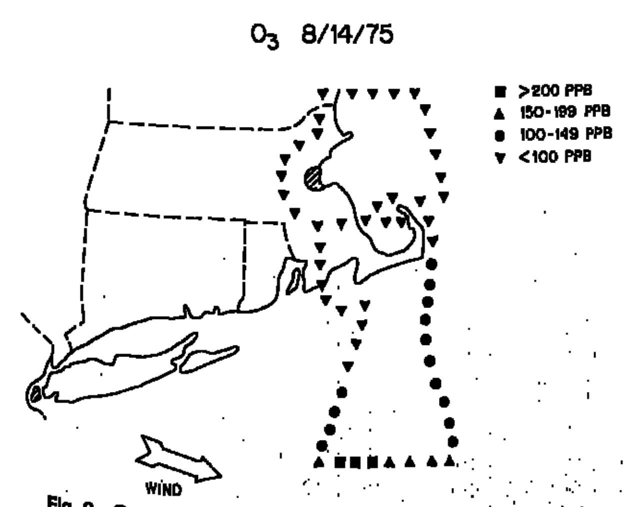


Fig. 3. Ozone concentrations at 330-490 m altitude off the coast of the northeastern United States on the afternoon of August 14, 1975. The highest concentrations were seen about 250 km east of the New York City metropolitan complex, a region of high precursor emission fluxes. Trajectory analysis demonstrated that the high ozone air mass passes over the metropolitan area during the morning of the day on which measurements were made. (After G. W. Siple, C. K. Fitzsimmons, D. F. Zeller, and R. B. Evans, *EPA-600/3-777-001a*, Environ. Prot. Agency, Research Triangle Park, N.C., 1977.)

While many uncertainties remain, over the last decade great strides have been made in our understanding of the atmospheric cycles of the carbon compounds CH_4 and CO, nitrogen oxides, ozone, and halogens. In each of these cycles, it has been found that OH plays a major role, and thus understanding the processes that control the OH abundance is of major importance. Because of its reactivity, the concentration of OH at any location is determined by a balance between photochemical production and destruction. OH production occurs as a result of the photolysis of O_3 to produce a metastable oxygen atom ($O(^1D)$) followed by the reaction of $O(^1D)$ with H_2O. Reactions of OH with CO and CH_4 are generally the major loss processes for OH in the remote troposphere. O_3 and NO can lead to a further enhancement in OH levels by regenerating OH from HO_2, the HO_2 having been produced by the CO and CH_4 reactions with OH. Thus, an understanding of OH concentrations in the atmosphere requires a corresponding understanding of the atmospheric distributions of O_3, H_2O, CO, CH_4, the nitrogen oxides, and perhaps the array of atmospheric hydrocarbons.

The recent National Science Foundation-sponsored Global Atmospheric Measurements Experiment of Tropospheric Aerosols and Gases (GAMETAG) included simultaneous measurements of OH and many of the parameters that influence OH concentrations: CO, CH_4, O_3, H_2O, ultraviolet flux, etc. Thus this experiment, by allowing a direct comparison of measured and model-calculated OH, has made possible the first quantitative test of the photochemical theory of tropospheric OH. Results for the tropical and subtropical marine boundary layer are quite encouraging. It is suggested, however, that a future project consisting of a more comprehensive set of trace gas measurements would afford a more rigorous test of OH chemistry and of other fast photochemical processes. It is also noted that a vigorous observational program to elucidate the detailed global distributions of key trace gases and their sources and sinks is still a major need in this field, as is the continued development of sophisticated photochemical models to analyze and simulate these data.

Barry J. Huebert (Colorado College) considered the 'Aerosol Chemistry of the Troposphere.' Because so many gases that cycle through the troposphere pass through a condensed phase at some point, we cannot fully understand their geochemical cycles without understanding their aerosol phases. Current areas of aerosol research include (1) measurements of particle sizes, compositions, and spatial distributions; (2) studies of the effect of aerosols on visibility, climate, and precipitation chemistry; and (3) investigations into the role aerosols play in trace gas chemistry.

In many cases the aerosol phase is a sink for trace gases. This gas-to-particle conversion includes such processes as the nucleation of new particles (after the reaction of SO_2 with OH, for instance), the condensation of gases onto existing particles (as in the adsorption of HNO_3 onto aerosols), and the heterogeneous reaction of adsorbed gases on particles that serve as catalysts. Aqueous phase chemistry can occur in the liquid layer surrounding solid particles in mists, fogs, and clouds.

Aerosols are not only sinks for gases, they can serve as a source when volatile gases are formed on or in the aerosol (as in the release of HCl from seaspray) or when cloud droplets evaporate and release their dissolved gases.

We are only just beginning to appreciate the complex role of aerosols in the chemistry of the troposphere. Although we qualitatively understand the processes by which aerosols interact with atmospheric gases, our quantitative understanding is quite poor. Some models for aerosol growth do give fair agreement with chemically simple systems, but current models are generally unable to predict the relative rates of nucleation, condensation, and coagulation of the complex aerosols in the real atmosphere. We need better thermodynamic data for the impure condensed phases that form, as well as much additional theoretical and experimental work on the growth processes. Until we can predict gas-to-particle and particle-to-gas conversion rates, we will be unable to include meaningful source and loss terms in atmospheric trace-gas models. The situation is only slightly better for the measurement of aerosol composition and concentration. Although some nonvolatile, noncondensible compounds can be collected and speciated nicely, many aerosol measurements are haunted by positive or negative artifacts from the sampling process. Aerosol chemistry desperately needs techniques that can identify specific chemical species in in situ aerosols.

Ralph J. Cicerone (National Center for Atmospheric Research) summarized the 'Photochemistry of the Stratosphere' (the region of the atmosphere between 10 and 50 km above the surface). The stratosphere's chemistry is controlled by the fluxes of gases from the troposphere and the mesosphere and by their interaction with solar ultraviolet and visible radiation. A major concern of scientists is the photochemistry of stratospheric O_3, and the possible inadvertent depletion of O_3 owing to various anthropogenic activities (e.g., high flying supersonic transports, man-made chlorofluoromethanes (CFMs), and nitrogen fertilizers used in agriculture). About 90% of the total atmospheric O_3 is found in the stratosphere. As was already pointed out, stratospheric O_3 protects the surface of our planet from solar ultraviolet radiation (200—300 nm).

The production of stratospheric O_3 is initiated by the photolysis of molecular oxygen (O_2) by solar ultraviolet radiation ($\lambda < 242$ nm), resulting in the formation of two oxygen atoms (O). The oxygen atoms recombine with O_2 to form O_3. Stratospheric O_3 is destroyed via photolysis and by reaction with atomic oxygen. In addition, stratospheric O_3 is destroyed by reactions with species present in trace amounts, thousands of times less abundant than O_3 itself. These species enter into catalytic cycles in which one molecule can destroy many O_3 molecules before being removed itself. These catalytic cycles involve the oxides of nitrogen (NO_x), hydrogen (HO_x) and chlorine (ClO_x). The major source of stratospheric NO_x is the reaction of nitrous oxide (N_2O) with excited atomic oxygen. Nitrous oxide is produced by the action of microorganisms at the surface of the earth. The major source of HO_x in the stratosphere is the reaction of excited atomic oxygen with water vapor (H_2O). The major source of stratospheric ClO_x is the photolysis of man-made chlorofluoromethanes (CFMs) (e.g., $CFCl_3$ and CF_2Cl_2). Current model results suggest that the CFMs produce the largest ozone depletion. As updated information becomes available, model results fluctuate, however, as is shown in Figure 4. Inadequate computational power and the sparseness of stratospheric data will combine to make improved assessment difficult over at least the next few years.

'Particulates in the Middle Atmosphere' was the topic discussed by Richard P. Turco (R&D Associates). The middle atmosphere — the stratosphere and mesosphere between 15 and 90 km — is now known to contain a rich variety of particulate matter (Figure 5). Neutral and charged clusters of molecules, with radii ranging from 2 to 10 Å, are the most diminutive of atmospheric particles. Clustered positive and negative ions may combine to form stable multi-ion complexes with sizes between 10 and 50 Å. Meteoric smoke, which is produced by the ablation of interplanetary debris entering the upper atmosphere at high velocity, also occupies the small size range from about 5 to 100 Å. Micrometeorites that survive atmospheric entry dominate the size spectrum from about 1 to 10 μm. Sulfate aerosols of photochemical origin are present in a narrow layer between 15 and 25 km altitude. These volatile particles can grow to sizes of 0.1 to 1 μm. Volcanoes occasionally inject large quantities of ash and sulfur-bearing gases into the middle atmosphere. Such events can significantly increase the aerosol burden for a year or more.

Man can affect the concentrations of aerosols in the middle atmosphere both by direct injection of particles and by emission of gases that can condense into particles. Aluminum oxide dust from rocket engines has been found in large quantities at 20 km. Some industrial gases such as carbonyl sulfide and carbon disulfide can reach the stratosphere, then

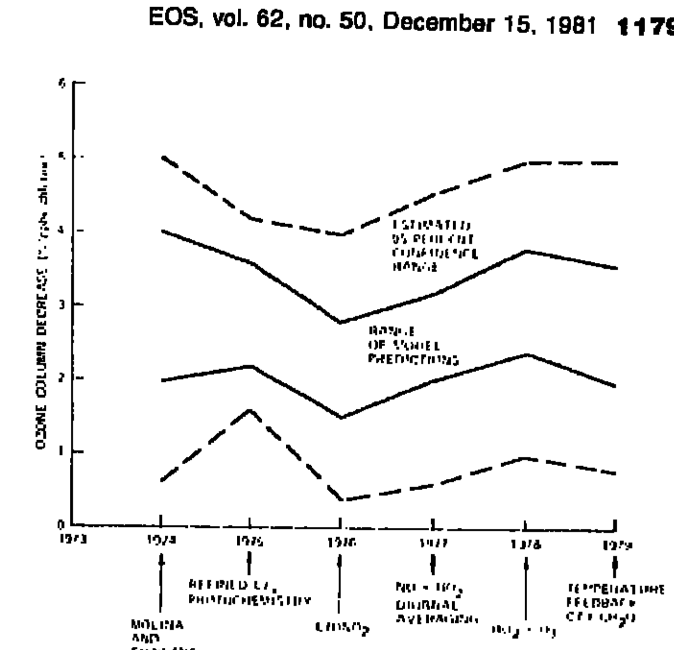


Fig. 4. Theoretical predictions of the eventual decrease in stratospheric ozone as a function of the time at which the prediction was made (courtesy of R. P. Turco).

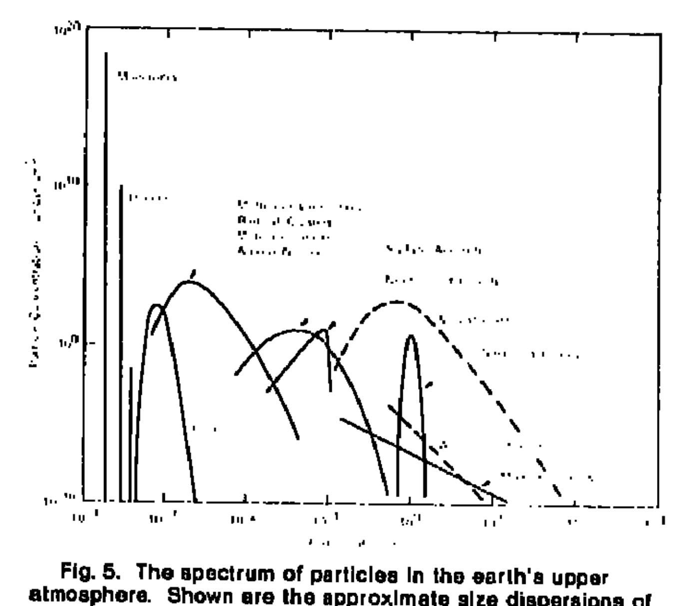


Fig. 5. The spectrum of particles in the earth's upper atmosphere. Shown are the approximate size dispersions of particles of different origins. The total number concentration of each type of particle is roughly indicated by the peak value indicated on the vertical scale (courtesy of R. P. Turco).

decompose, and subsequently form new sulfate aerosols.

A number of possible mechanistic roles have been suggested for the particles in the middle atmosphere. They may (1) serve as reaction sites for gases, (2) act as a sink for gases, (3) influence the global radiation balance, (4) nucleate nacreous and noctilucent clouds, and (5) provide a link between solar emission variations and tropospheric weather. Of these possibilities, only the second and third are well established at present, although the others are under active experimental and theoretical investigation.

Since the discovery of the permanent, ubiquitous stratospheric sulfate aerosol layer by Junge and coworkers two decades ago, these particles have been a subject of intense study using both in situ and remote sensing techniques. On the basis of such observations, we can say that the aerosols are probably composed of a 75% sulfuric acid aqueous solution, with an admixture of a variety of materials ranging from meteoric debris to nitrosyl compounds derived from stratospheric NO_x. The mode of nucleation of the aerosols is uncertain and may involve tropospheric (Aitken), meteoric, ionic, and sulfur radical nuclei. The growth of the aerosols is largely controlled by the oxidation of sulfur-bearing gases which are transported into the stratosphere from the troposphere. The primary gaseous aerosol precursors are sulfur dioxide and carbonyl sulfide, both of which may have significant anthropogenic sources.

The effects of stratospheric aerosols on the global radiation balance are most noticeable following major volcanic eruptions, when the aerosol layer may be enhanced to the point that substantial temperature variations occur at the earth's surface. The May 18, 1980, eruption of Mt. St. Helens created dust-darkened skies and brilliant sunsets, dramatically demonstrating the optical perturbations that can be caused by volcanic aerosols. Recently, an increasing trend in the optical density of the background (nonvolcanic) aerosol layer has been identified; one possible explanation is man's increasing usage of fossil fuel, with the attendant release of sulfur compounds to the atmosphere.

In a talk entitled 'Photochemistry of the Mesosphere and Thermosphere,' Douglas G. Torr (Utah State University) pointed out the influence of new data, largely acquired or stimulated by satellite experiments, on the understanding of thermospheric chemistry. At the end of 1979, that chemistry appeared to have crystallized into a clearly understood form, mainly as a result of analyses conducted with data taken by the Atmospheric Explorer (AE) C, D, and E satellites. To maintain consistency with laboratory measurements of the processes that destroy the N_2^+ ionization, it was found that the rate coefficient for the charge exchange reaction

$$O^+(^2D) + N_2 \xrightarrow{k_1} N_2^+ + O$$

must be less than 10^{-10} cm^3 s^{-1}, that is, an order of magnitude smaller than earlier laboratory measurements conducted by using nonthermal O^+ ions. However, during the course of the last year new laboratory measurements established k_1 to be $\sim 8 \times 10^{-10}$ cm^3 s^{-1} (i.e., an order of magnitude larger than the aeronomically deduced value). Inclusion of this new value for k_1 in the ion chemistry introduced several problems, namely excess production of N_2^+ ions and a shortfall in production of $O^+(^4S)$ ions, which caused a deficiency in the concentrations of both NO^+ and O_2^+ ions. These appear now to have been simultaneously resolved with the inclusion in theoretical models of rapid charge exchange between vibrationally excited N_2^+ and oxygen atoms. The previously anomalous seasonal behavior of the F_2 layer on a global scale appears also to be explained by this new approach.

Torr reported that a major step forward in the laboratory measurement of rate coefficients was that of E. C. Zipf (University of Pittsburgh), who used laser induced photofluorescence techniques to study the behavior of N_2^+ ions in specifically identified vibrational and rotational quantum states. The specific dissociative recombination coefficients for the $v = 0$, 1, and 2 vibrational levels of the $N_2^+ (X^2\Sigma_g^+)$ state were found to be nearly equal in magnitude, thereby placing significant constraints on allowable thermospheric models. In the case of O_2^+, Zipf used indirect techniques to study the production of $O(^1S)$ via O_2^+ recombination and found very little production in the $v = 0$ level, implying that high $O(^1S)$ yields are associated with recombination in high vibrational levels. The $O(^1S)$ yield inferred from the AE data is large, but vibrationally excited O_2^+ is believed to be strongly quenched by atomic oxygen in the thermosphere. To explain this inconsistency, a dependence of the $O(^1S)$ yield on electron temperature has been tentatively suggested.

In the area of neutral thermospheric chemistry, recent developments include the finding that the forbidden predissociation of the numerous $^1\Pi_u$ and $^1\Sigma_u$ valence and Rydberg states of N_2 in the 11-24 eV range via radiation entrapment in an optically thick atmosphere is the dominant mechanism for N_2 atom production, the finding that destruction of $N(^2D)$ constitutes a major source of OI 6300 Å dayglow, and the discovery of an oxygen geocorona of ~3000 to 4000°K.

Mesospheric chemistry has not received as much recent emphasis as has thermospheric chemistry, mainly because the necessary experimental effort has been planned for the 1980's. Some recent results have provided new insights, however. A reevaluation of the O_2 dissociation rate has yielded ratios of 1 and 0.6 for the old to new rates at the altitudes 80 and 50 km, respectively. Similar results for the dissociation rate for water vapor indicate that the uncertainties are such that the actual rates may be as low as 0.45 or as high as 1.55 times the currently accepted values.

In an analysis of solar proton events, it has been recently pointed out that above ~75 km the rate of dissociation of water vapor produced by recombination of hydrated ions may be large enough to deplete H_2O concentrations significantly, since the odd hydrogen at these altitudes is effectively lost in conversion of H_2 by the reaction

$$H + HO_2 \rightarrow H_2 + O_2$$

The net result would be an initial depletion followed by a storm time increase in ozone.

Terrestrial Planets: Venus and Mars

Planetary atmospheric chemistry at the symposium was introduced by Ronald G. Prinn (Massachusetts Institute of Technology), who discussed the 'Chemistry of the Atmosphere of Venus.' The atmosphere is dominated by CO_2, N_2 at ~3.4% being the next most abundant constituent. HCl and HF were detected by ground-based spectroscopy in 1968; their presence is consistent with what one would derive by heating earth rocks to the 750°K Venusian surface temperature. CO is also present, primarily as a result of CO_2 photolysis; other suggested sources are lightning and thermochemistry near the surface. Water vapor is present at concentrations of a few parts per million above the clouds and a few hundred parts per million below the clouds.

The recent Venera and Pioneer Venus probes confirmed earlier suggestions of a rich sulfur chemistry in the Venusian atmosphere by detecting SO_2 and, more tentatively, H_2S, S_3, and S_4 below the clouds. Collaborative evidence for concentrated sulfuric acid as a major component of the clouds of Venus was also provided. The ultimate source of the sulfur is undoubtedly outgassing of the crust, perhaps partially by volcanism. This outgassing is expected to be in the form of H_2S and OCS. The latter gas has not yet been observed but would be expected at altitudes below 20 km (where measurements are presently lacking) due to equilibration of the observed CO, S_3, S_4, and SO_2.

It appears that photochemical oxidation of SO_2 and, to a lesser extent, H_2S is the major source of the sulfuric acid in the clouds and the major sink for the O_2 produced from CO_2 photodissociation at high altitudes. The major sink for CO appears to be oxidation to CO_2 by reactions with SO_3, SO_2, and SO near the surface. The Venera spectrophotometers indicated that the water vapor mixing ratio decreases as one approaches the surface. This property may be linked to photodissociation of S_3 and S_4 by near ultraviolet and visible light below the clouds. Collaborative laboratory studies are required.

The chlorine chemistry of the Venus atmosphere, although studied for some years, is more poorly understood than that of the earth. The 1 ppm of HCl that is present will photolyze to produce both odd hydrogen and odd chlorine radicals. These latter species are expected to play some role in the oxidation of SO_2 at cloud level, but the exact mechanisms are not yet known. The much lower O_2 concentrations on Venus will render Cl much more abundant than ClO, in contrast to the situation in the earth's atmosphere.

The clouds of Venus possess a complex structure as a function of altitude (Figure 6) and appear to be composed of several different chemicals as well. These points were discussed by Owen B. Toon (NASA Ames Research Center) in his talk 'Chemistry of the Clouds of Venus.' The upper clouds are largely sulfuric acid, but the particle size distribution is bimodal with peaks at ~0.1 and 1.0 μm, a distribution that pure sulfuric acid chemistry apparently cannot reproduce. This implies the presence of another constituent. Sulfur particles violate several observational constraints and cannot provide the opacity needed to explain the ultraviolet markings on Venus. A candidate compound is Cl_2.

The lower clouds are characterized by a trimodal

VERTICAL STRUCTURE OF VENUS CLOUD SYSTEM

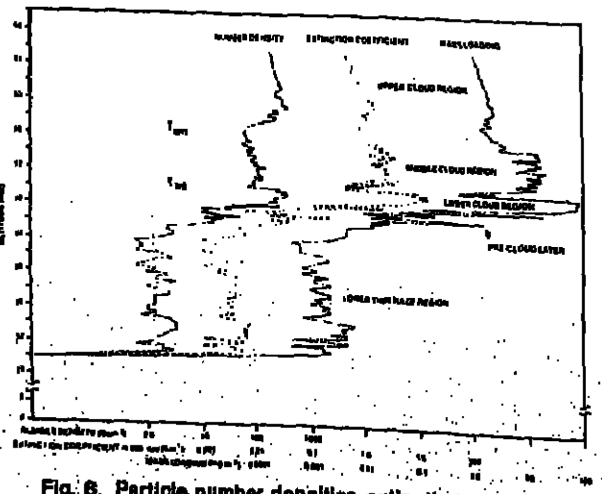


Fig. 6. Particle number densities, extinction coefficients, and mass loadings of the clouds of Venus (courtesy of R. Knollenberg).

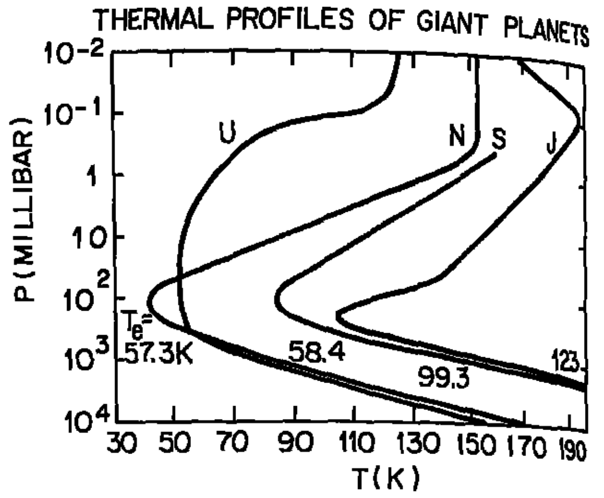


Fig. 7. The thermal structures of the Jovian planets. (D. Gautier and R. Courth, *Icarus, 39*, 28, 1979; reproduced by permission of Academic Press.)

particle size spectrum with peaks at ~0.01, 0.1, and 0.6 μm. Again, sulfuric acid fails as a controlling species in such a trimodal regime. The clouds appear to be partly sulfuric acid, but most of their mass is contained in an unidentified solid, transparent compound composed of at least Cl, O, and S.

Severe difficulties are encountered when trying to model the cloud chemistry. Present models are reasonably successful at reproducing the observed upper level sulfuric acid clouds, but are unsuccessful at producing the observed vertical profiles of O_2, CO, and SO_2, the abundance of Cl_2, required to explain the observed ultraviolet absorption, or any solid chlorine compounds in the lower clouds. Theoretical and laboratory studies are required to improve the models, but major questions remain for future spacecraft missions to resolve.

Next to the earth's present atmosphere, that of Mars is probably the best understood. In a talk entitled 'Photochemistry of the Martian Atmosphere,' T. Y. Kong (Bell Laboratories) pointed out some of the distinctions between them. The atmosphere of the earth is controlled by four processes: photochemical, physical, biological, and anthropogemic. On Mars, only the first two of these appear to exist. As a result, Mars has not developed an oxygen-rich atmosphere, but maintains a thin atmosphere (surface pressure 8 mbar) dominated (96%) by CO_2. About 4% of the atmosphere is N_2 and Ar.

The low opacity of the Martian atmosphere (except during dust storms) promotes photochemical processes, with such species as O_3, CO, and NO being observed as a result. Much of the driving force for this chemistry comes from the photodissociation of CO_2 and H_2O. Model calculations have been reasonably successful at treating such features as the wide variation (up to a factor of ~30) of low-altitude ozone concentrations at different latitudes and seasons. At high altitudes, the dominant form of odd oxygen is predicted by the models to be the oxygen atoms. The dominant form of odd hydrogen near the ground is HO_2, not unlike the troposphere of the earth. Still to be investigated are the ways in which Martian dust influences the chemistry of the Martian atmosphere.

The Jovian Planets

D. F. Strobel (Naval Research Laboratory) discussed the atmospheres of the Jovian planets, with special emphasis on Jupiter. The thermal structures of the Jovian planets (Figure 7) differ principally in the temperature offset owing to solar distance. Their composition is dominated by H_2 and He. Jupiter and Saturn have recently been the subjects of Voyager flyby analyses; combined with ground-based observations, these indicate the presence of CH_4, C_2H_2, C_2H_6, NH_3, and PH_3 in the atmospheres of both planets. In addition, CO has been detected in the Jovian atmosphere.

The observations can be compared with theory by using the deduced thermal structure, assuming thorough atmospheric mixing to great depths, and invoking chemical reactions that link the observed species. For Jupiter, this is done by starting with a parcel containing a variety of volatile constituents at an interior reference level of p = 200 kbar, T = 2000°K, allowing the parcel to ascend adiabatically, and calculating the levels at which the various liquid and solid phases condense out. The condensates are assumed to remain as aerosols at these levels. Dense water clouds are calculated to form at 270°K, 60 km above the 'surface' reference level where p = 20 bar. Near the 200°K (90 km) level H_2S is thought to react with NH_3 to form a cloud of solid NH_4SH particles. White crystals of ammonia precipitate out at 154°K (p = 800 mbar, z = 120 km) to produce the visible upper cloud layer, a result supported by lines characteristic of solid ammonia in Jupiter's emission spectra.

It appears that many of the Jovian trace molecules are created high in the atmosphere (where solar photons are readily available) and are mixed down into the lower atmosphere. The color of the Great Red Spot and of some of the clouds is presumably a result of phosphorus chemistry, although compounds of sulfur have also been suggested. Analyses of the hydrocarbon chemistry are complicated by two factors: uncertainty in the photochemistry of C_2H_2 and C_2H_3 and the possibility of chemical effects from precipitating magnetospheric particles. Ongoing analyses of the Voyager data may place constraints on some of these processes.

The photochemistry of the atmospheres of Saturn, Uranus, and Neptune have received much less attention than has that of Jupiter and were not explicitly discussed at the symposium. There is every indication that similar approaches can be used to describe the chemistry of all the Jovian planets, however. All contain small hydrocarbons and probably ammonia. Spurred on by the wealth of Voyager data, they will no doubt be actively modeled over the next several years.

Titan, Triton, and Pluto

Little has been known of the atmospheres of these three bodies, and they have received little study as a result. The paucity of information was dramatically reversed for Titan by the Voyager I flyby in November 1980. Previously thought to contain mostly methane, the atmosphere was found to be almost entirely N_2. Trace amounts of CH_4, C_2H_2, C_2H_4, C_2H_6, and HCN were also detected by Voyager I, proving conclusively the existence of hydrocarbon photochemistry on Titan. The surface temperature and pressure, atmospheric scale height, and the presence of a 75°K temperature minimum at ~50 km were also established. Theoretical studies aimed at matching these observations and thus establishing the atmospheric chemical mechanisms are being vigorously pursued.

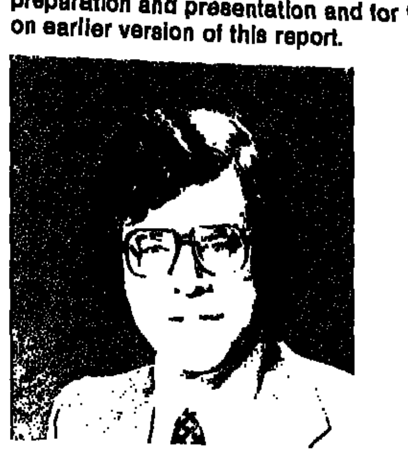
Triton and Pluto are known to possess frozen methane on their surfaces. At surface temperatures of 50°—70°K, the methane vapor pressure from this methane ice will provide tenuous atmospheres. It is reasonable to suppose that the unobserved gases N_2, H_2, and Ar will be present as well. Until more detailed experimental observations can be obtained, little information will be forthcoming on the atmospheric chemistries of Triton and Pluto.

Summary

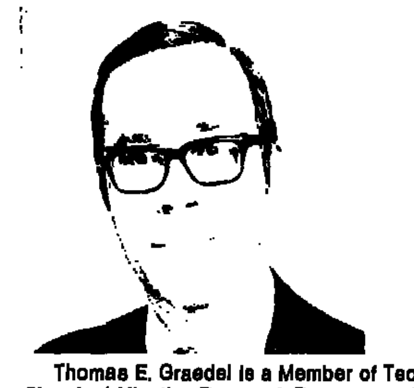
The photochemistry of planetary atmospheres has come of age in the last decade. From a single example, the modern atmosphere of the earth, the vigorous programs of planetary exploration have provided data on the atmospheres of Venus, Mars, Jupiter and Io, and Saturn and Titan. In addition, studies of geological records have provided substantial inferential information on the ancient atmosphere of the earth. Although we can still look forward to the observations of Voyager 2 of Uranus, Neptune, and Triton, eight examples of planetary atmospheres are available to the theoretical photochemist. Their similarities and their differences provide striking examples of the concomitant diversity and scientific rigor of nature.

Acknowledgments

The symposium on which this report is largely based was ably chaired by R. J. McNeal, Manager of the Air Quality Program at NASA Headquarters. We thank him for his efforts. Our thanks also go to the symposium participants, both for their careful preparation and presentation and for their comments on earlier version of this report.



Joel S. Levine is a Senior Research Scientist in the Atmospheric Environmental Sciences Division at the NASA Langley Research Center, Hampton, Virginia. He received a B.S. (Physics) from Brooklyn College, a M.S. (Meteorology) from New York University, a M.S. (Aeronomy and Planetary Atmospheres) and Ph.D. (Atmospheric Sciences), both from the University of Michigan. His current research interests are the origin and chemical evolution of atmospheres and the photochemistry of the troposphere, particularly assessing the impact of anthropogenic activities. He is the Principal Investigator of the Atmospheric Chemistry Experiment (ACE) aboard the NASA F-106B Storm Hazards Project aircraft, which recently obtained samples of air prior to, and during, a series of flights through thunderstorm lightning (the aircraft was struck by lightning several times!). He is involved in the formulation and implementation of NASA's programs in both tropospheric and atmospheric evolution research. A member of the AGU since 1960, he serves on the Geophysical Monograph Board.



Thomas E. Graedel is a Member of Technical Staff in the Chemical Kinetics Research Department, Bell Laboratories, Murray Hill, New Jersey. He holds a B.S. (Chemical Engineering) from Washington State University, a M.A. (Physics) from Kent State University, and M.S. and Ph.D. degrees (Astronomy) from the University of Michigan. His current research interests are in computer modeling of the chemistry of the earth's troposphere and in experimental and theoretical investigations of atmospheric corrosion of metals and alloys. A member of AGU since 1965, he has served as Chairman of the Geophysical Monograph Board and is presently the Chairman of the Books Board and a member of the Publications Committee.

News

Volcano Organization Formed

The past decade was an unusually eventful one for volcanology, with the 1973 eruption on Heimaey, Iceland, the 1976–1977 rumblings of the Soufrière Volcano on Guadeloupe, the huffing and puffing of Iceland's Krafla Volcano in 1975, the many eruptions of Mount Etna in Sicily in the 1970's, and the reawakening of Mount St. Helens in 1980 in the United States. In addition to their scientific duties, volcanologists have had to play an important social role as advisors to administrators. For example, the political decision to evacuate Guadeloupe exposed French volcanologists to scrutiny more severe than previously experienced by members of the profession. These volcanologists met the challenge by completely reorganizing their volcano observatories and by increasing their volcano research.

In recognition of this recent reorganization and the associated modernization of volcano observatories on Guadeloupe and Martinique, the French government invited representatives from the world's volcano observatories and institutions to meet. The meeting, from February 18–21, 1981, resulted in the establishment of the World Organization of Volcano Observatories (WOVO). As its name implies, WOVO is concerned exclusively with volcano observatories and volcano monitoring; its activities will not duplicate the functions of existing international organizations, such as the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), which focus generally on volcanology and allied topics.

The principal objectives of WOVO are to create or improve ties between observatories and institutions directly involved in volcano monitoring; to facilitate the exchange of views and experiences by convening periodic, perhaps annual, meetings; to maintain an up-to-date inventory of instrumentation and manpower, which could be made available to any of the member institutions if a situation arises that requires scientific reinforcement; and to promote funding from international organizations, which could help to defray travel and related expenses of scientific reinforcement teams.

Representatives from Costa Rica, France, Iceland, Indonesia, Italy, Japan, Portugal, Mexico, and the United States attended the meeting. Ecuador, New Zealand, the Philippines, Tobago, and Trinidad also have expressed interest in WOVO. Any country can join the organization as a founding member until the next meeting, planned for August 1982, in Iceland in conjunction with the IAVCEI/IAGC meeting.

Two working groups convened during the Guadeloupe organizational meeting. A group on monitoring strategy, composed of L. A. Mendes Victor (Portugal, chairman), J. L. Cheminee (France), A. Sudradjat (Indonesia), and I. Yokoyama (Japan), met to define a general strategy for monitoring regions where many volcanic events have occurred throughout history. The group also sought to define basic institutional cooperation while strengthening observational systems and promoting fundamental prediction research. Among the recommendations offered by the group are (1) that a country with many active volcanos must define the priority of action according to the volcanic hazard; (2) that some major volcanic areas be equipped with advanced observation systems with continuous seismic recording stations; (3) that regional understanding of seismicity can provide an adequate information basis for decisions concerning the mobilization of national or international cooperation programs for monitoring specific areas for short periods; (4) that nationally coordinated geophysical institutions will facilitate the observation of geophysical phenomena over large areas, but information exchange must be rapid to take appropriate action; and (5) that the history of active volcanos be studied and the recurrence of events be evaluated on a statistical basis.

The second working group concerned itself with defining the 'adequate minimum' equipment and personnel for a volcano observatory. Given the premise that any monitoring is better than none, the working group—composed of R. Tilling (U.S., chairman), M. Espendola (Mexico), E. Malavassi (Costa Rica), L. Villari (Italy), and J. P. Viode (France)—unanimously agreed that continuously recording monitoring systems are absolutely essential for timely volcanic hazards warnings. The adequate minimum systems should include a seismic network of three stations (short-period, vertical seismometers and associated telemetry and recording systems) to locate the foci of seismic activity; a simple tremor or seismic alarm system to alert staff at night, and a continuously recording tiltmeter with associated radio-link telemetry. For calibration, the system also should have at least one nonelectronic tilt-measurement array. Adequate minimum staff was defined by the group to be two geoscientists, one specializing in geophysics seismology and another in geology geodesy; one electronics engineer or technician; and two general purpose, physical science technicians. The group also deemed desirable, to augment the minimum monitoring, periodic reoccupations of a network of 'dry tilt' stations, a modest trilateration (geodimeter) network, and a few leveling lines; observations of physical changes in the volcano's vicinity; collection of information resources, documentation, and manuals for instruments and monitoring techniques; and study of historical records to ascertain eruptive patterns.

Gudmundur E. Sigvaldason of Iceland was elected president of WOVO's executive board; other members are Tilling, Yokoyama, and J. L. Le Mouel (France).

For additional information on WOVO, contact Sigvaldason, Nordic Volcanological Institute, Geosciences Building, University of Iceland, Reykjavik, Iceland.

This news item was contributed by G. E. Sigvaldason and is a compilation of reports by L. A. Mendes Victor of Portugal and Robert Tilling of the U.S. Geological Survey.

Luck + Merit = Grant

Granting approval to proposals submitted to the National Science Foundation (NSF) depends about as much on luck as it does on the scientific merit of the proposal, according to a study by the National Academy of Sciences' Committee on Science and Public Policy (COSPUP). In addition, concealing the names of the authors of the proposals, a practice known as 'blinding,' would not significantly change the outcome of the grant-awarding process.

'The fate of a particular grant application is roughly half determined by the characteristics of the proposal and the principal investigator, and about half by apparently random elements which might be characterized as the "luck of the reviewer draw," ' according to Stephen Cole, Jonathan R. Cole, and Gary A. Simon in the COSPUP report summary, published in the November 20 *Science*. If researchers' proposals for NSF grants were rated again by an equally qualified group of reviewers, between 25% and 30% of NSF funding decisions could be reversed, they said.

However, 'this should not be interpreted as meaning either that the entire process is random or that each individual reviewer is evaluating the proposal in a random way,' they continued. To clarify the way in which the luck of the draw works, the report's authors suggest that the sources of reviewer disagreement be scrutinized.

'The great bulk of reviewer disagreement observed is probably a result of real and legitimate differences of opinion among experts about what good science is or should be. . . . As long as substantial reviewer disagreement, whatever its source, exists the fate of a particular proposal will depend heavily upon which reviewers happen to be selected,' state Cole, Cole, and Simon.

COSPUP also found that 'reviewers at major institutions did not treat proposals from applicants more favorably than did reviewers from lesser institutions.' They found, in fact, the opposite trend. Length of career had no strong effect on the probability of receiving a grant. In addition, there was

low or moderate correlation between the funding decision and the prestige rank of the applicant's current academic department, academic rank, geographic location, NSF funding history during the previous 5 years, and the location of doctorate training.

Given the chance of the review process, it would appear that the more proposals a scientist submits to NSF, the more likely it is he or she will be funded. 'In fact,' Cole, Cole, and Simon said, 'eminent scientists may be more likely to be funded than less well-known ones not because their probability of success is greater for each submitted proposal, but because they submit many proposals and are not deterred by an individual rejection.'

Would a 'blind' review system be better? In general, COSPUP found that 'it was extremely difficult to conceal the authorship of proposals,' and that reviewer disagreement, not blinding, played a greater role in their study.

What does all of this mean for science? 'A distinction must be made between the effect of randomness in the peer review system on individual applicants and the effect on science itself,' according to the report summary. While the randomness may be frustrating to individual scientists, 'it may have little effect on the rate of development of science as a whole, wrote Cole, Cole and Simon. 'One clear disadvantage for science of the current peer review system is that it compels even our most talented scientists to spend substantial amounts of time and energy writing proposals, time and energy that might be more fruitfully spent doing research.'—*BTR*

NSF Reviewed—An Analysis

The awarding of scientific research grants jointly to investigators and their academic institutions by the National Science Foundation (NSF) (see news item above) is based on a concept of high ideals; review of proposed research ploys is done by peers selected from the academic community. The peer review process and the way awards of funds are made to an investigator's institution are often mildly criticized, but among members of the community there has long been an underlying respect of the concepts, a recognition that the process tends to lead to high standards in research. As peers are chosen, a certain degree of unevenness in the review process is to be expected. Just how much unevenness has been revealed in a recent study sponsored by the National Academy of Sciences Committee on Science and Public Policy (COSPUP). The results indicate that the peer review process is random and unbiased. The results show some tendency toward unevenness between groups of peers, but the NSF process evidently is a finely tuned one, especially when compared with other more or less subjective methods of evaluation.

The choice and selection of reviewers of a proposal is, by necessity and intention, subjective in certain ways. The reviewers must know the field, the specifics of the proposed research, and they must be competent to judge the investigator and the institutional facilities. To do this, the reviewers must be subjective, bordering on a conflict of interest. And yet, the study showed there was little, if any, bias toward proposers. There was a measureable component of what the study called 'luck of the reviewer draw,' which was seen when a given set of research proposals was evaluated by more than one group of reviewers. If the selection of reviewers was random, then the reviews were uneven. The modifying subjectivity is the thoughtful choice of reviewers by the NSF program directions. This has been called 'informed subjectivity' (*Chemical and Engineering News*, Nov. 16, 1981). Reviewer disagreement seemed to be mostly 'a result of real and legitimate differences of opinion among experts about what good science should be.' There is no guarantee that a given proposal will be judged the same by several sets of reviewers, and yet the report states . . . 'this should not be interpreted as meaning either that the entire process is random or that each individual review is evaluating the proposal in a random way.'

Even though the NSF-peer review system has proven to be a fair judge of research proposals, the investigator whose budget is severely cut or whose proposal is turned down will get little solace from the results of a survey. That there is some degree of randomness or chance in the outcome serves to provide a smoothing function to the overall process. Chances improve with statistics and with the number of reviews of a given proposal. The report states: '. . . given the importance of chance in the current process, clearly the more proposals a researcher submits the higher the probability of being funded.' Thus there is good news that an investigator should not be deterred by the rejection of proposals.

Perhaps the most important outcome of the study is that the review process is a good one and is working. The questions or problems that arise are more sophisticated and subtle than factors revealed by a statistical study. They have to do with the correspondence between the research proposed and the research actually done, the attempt to judge creativity before it is created and the obvious question of trying to prejudge a result that cannot be predicted beforehand. The review process is influenced by the 'zero-based' budget syndrome; a new budget per year means a new proposal to be reviewed per year, which must not only reflect new findings per year but a new project per year. The result may be that science is being done on a short project one-per-year basis. Longer, perhaps more fundamental, and thus more vaguely proposed research projects do not fit into the system too well. NSF-funded projects of 5 years or more duration are almost unheard of today.

It is clear, however, the shorter time of a project benefits from more rapid publication of the results, more critical response by the academic community, and a sharper competitive edge. The competitive spirit today in research is such that if an investigator were to take 5 years to publish results of his research, often someone else would have been first. The high level of excellence of scientific research in the United States has resulted in part from the competitive process that, in turn, is fostered by the NSF peer review process.—*PMB*

AGU Members Receive Fulbrights

Five AGU members were granted senior Fulbright awards for university teaching and advanced research abroad for 1981–1982, according to the U.S. International Communications Agency and the Board of Foreign Scholarships.

Yvonne Herman-Rosenberg, associate professor of geology at the Washington State University in Pullman, will research Black Sea Quaternary benthoic foraminifera as indicators of sea-level fluctuations. The research will be conducted at the University of Bucharest in Romania from May through July, 1982.

George V. Keller, professor of geophysics and head of department at the Colorado School of Mines, is lecturing at the Moscow State University on exploration for geothermal energy. His 3-month stay in Moscow concludes this month.

Robert D. Lawrence, associate professor of geology at the Oregon State University in Corvallis, will lecture for the entire academic year at the University of Peshawar in Pakistan on structural geology.

Walter H. Munk, professor of oceanography at the Scripps Institution of Oceanography, will research ocean mapping by remote acoustic sensing for the entire academic year at the University of Cambridge in the United Kingdom.

Carl Wunsch, an oceanographer at the Massachusetts Institute of Technology, also will be at the University of Cambridge for the entire academic year. He will research the application of inverse methods, acoustic tomography, and satellite altimetry to the problem of determining ocean circulation through global measurement systems.

New Planet Missions May Be Halted

A December 2 report in the *Washington Post* states that George Keyworth, science advisor to President Reagan, has 'recommended halting all new planetary space missions for at least the next decade—an idea he said the White House seems to be buying.'

A spokesman in the Office of Science and Technology Policy (OSTP) told *Eos* that in keeping with this, astrophysics and astronomy, not planetary missions, would be emphasized in the fiscal 1983 budget. The OSTP spokesman was unsure what Keyworth meant by 'an idea the White House seems to be buying.' There has been other talk that budget cuts would jeopardize space exploration (*Eos*, October 20, p. 705).

Keyworth also has proposed the establishment of a new science advisory board at the White House. President Reagan has received the proposal, which calls for a 15-member panel similar to the President's Science Advisory Committee that was abolished by President Nixon in 1973. Reagan had not approved the proposal at deadline.—*BTR*

The June Bacon-Bercey Scholarship in Atmospheric Sciences for Women 1982–1983

Expressly for women intending to make a career in the atmospheric sciences. This monetary assistance provided through a gift from June Bacon-Bercey, a noted meteorologist, will be given to a woman who shows academic achievement and promise. To qualify candidates must be one of the following:

- a first-year graduate student in an advance degree program in atmospheric sciences;
- an undergraduate in a bachelor's degree program in atmospheric sciences who has been accepted for graduate study;
- a student at a 2-year institution offering at least 6 semester hours of atmospheric sciences, who has been accepted for a bachelor's degree program and who has completed all of the courses in atmospheric science offered at the 2-year institution.

For application forms contact:

American Geophysical Union
Member Programs Division
2000 Florida Ave., N.W.
Washington, D.C. 20009
462-6903
800-424-2488 outside the Washington, D.C. area

Awardee selection will be made by the AGU Subcommittee on Women in Geophysics, in consultation with the AGU Meteorology Section.

Application Deadline, May 1, 1982

Geophysicists

Robert L. Bates is the 1981 recipient of the Association of Earth Science Editors' Award for Outstanding Editorial or Publishing Contributions. Bates, formerly a professor of geology at The Ohio State University, is well known for 'The Geologic Column,' a regular feature in *Geotimes*. Previous recipients of the award are *Brian J. Skinner, Philip H. Abelson, Marie Siegrist,* and *Edwin B. Eckel.*

Philip S. Justus was promoted to section leader of the high-level radioactive waste repository section of the U.S. Nuclear Regulatory Commission in Silver Spring, Md. Before joining the Division of Waste Management, he was with the Geosciences Branch siting nuclear reactors.

John Rodgers, Silliman Professor of Geology at Yale University, was awarded the Geological Society of America's Penrose Medal for 1981. He was cited for his 'innovative ideas concerning Appalachian geology.' Rodgers is an AGU Fellow.

George H. Sutton, formerly professor of geophysics and associate director of the Hawaii Institute of Geophysics at the University of Hawaii, has been appointed vice president of Rondout Associates, Inc., in Stone Ridge, N.Y.

Donald L. Turcotte, president-elect of AGU's Tectonophysics Section, has been awarded the 1981 Arthur L. Day Medal of the Geological Society of America. The professor and chairman of the Cornell University Department of Geological Sciences was cited for 'distinguished application of chemistry and physics to geology.'

Richard M. Pearl, 68, died recently. A member of the Volcanology, Geochemistry, and Petrology Section, he belonged to AGU from 1953 to 1959 and from 1973 until his death.

New Publications

Process in Geomorphology

C. Embleton and J. Thornes (Eds.), John Wiley, New York, 436 pp., 1979, $44.95.

Reviewed by Avijit Gupta

As the title suggests, this is a process-oriented textbook in geomorphology, written by a team of six British geomorphologists: C. Embleton, J. Thornes, D. Brunsden, A. Warren, M. Clark, and B. Whalley. The trend in geomorphology over the last several decades has been toward a strong emphasis on the study and understanding of processes operating on landforms. This has resulted in the publication of a number of advanced and usually specialized volumes, for example, Leopold, Wolman, and Miller's classical textbook, *Fluvial Processes in Geomorphology*, which came out over 15 years ago. However, as the editors of this book describe in the preface, a detailed and comprehensive text that deals with all the major geomorphological processes, like fluvial, glacial, aeolian activities, etc., has been lacking. This volume is an attempt to fill the need for such a text at the advanced undergraduate level.

Students of geomorphology are often handicapped by their unfamiliarity with the concepts of mechanics or hydraulics, on which are based much of our understanding of the processes that explain the nature of landforms. The second and third chapters of the book attempt to tackle this problem by discussing the concepts of energy, force, resistance, and the nature of fluid motion. This is not an easy task, as a large amount of material has to be covered within about 50 pages: from basic definition of mass, velocity, force, etc., to complicated and empiric concepts of open channel flow. The results, unfortunately, are uneven and vary from succinct and rigorous presentation to brief, confusing, and occasionally simplistic summaries. For example, the utility, at the advanced undergraduate level, of a discussion on geomagnetism that takes only four and a half lines is, at best, debatable. On the other hand the boundary layer concept as presented in chapter 3 comes through relatively clearly, albeit in a somewhat generalized format.

Following these two prerequisite chapters comes the traditional arrangement of geomorphic processes, presented with a new insight and often unconventional format. The next two chapters on weathering and mass movements include an overwhelming volume of information, frequently collected from various case studies, often summarized in tables and highlighted by diagrams. These two, and a subsequent chapter on fluvial processes, are by far the longest ones in the book. The discussion on fluvial processes concentrates on river basin hydrology, the dynamics of sediment transport, and erosion and deposition both in stream channels and on hill slopes. The presentation, even of difficult topics, is usually lucid, but the impression one gets is that of unbalanced coverage. Even the author seems to have noticed this when on page 258 he attributes the lack of a proper discussion of floodplain development to a shortage of space. Presumably the shortage of space has also led to occasional terseness in presentation, which may easily confuse a reader. For example, the discussion on the sequence of channel bedform in noncohesive material after Simons and Richardson, can easily be misinterpreted by someone hitherto unfamiliar with the topic. Similarly one may conceive from the two paragraphs on hydraulic geometry that at-a-station change in width is always insignificant. The remaining chapters on subsurface, glacial, nival, aeolian, and marine processes are briefer, relatively less ambitious in their presentation, and in certain cases, not well structured or written.

The question that remains unresolved is that of readership. *Process in Geomorphology* includes an impressive amount of information, but the quality and style remain uneven, especially between chapters written by different authors. Furthermore, it is by no means an easy book to read. Such attributes as an extensive bibliography of over 30 pages, a considerable portion of which comes from European studies; the summarizing of many case studies in the text; the large number of tables that carry useful numerical information, often in comparative form; and the wealth of diagrams and superb photographs make it attractive to a teacher. One can envisage a university instructor incorporating a table or a diagram in his lecture, but he probably would not recommend this book as a text to his students. Apart from the difficult text and lack of rigor in presentation of mathematical formulae, the book does not stress the fact that our knowledge of geomorphologic processes is, to a great extent, based on empirical data collected in the field. There is a frequent disparity between the level at which one collects data and the level at which one's expectations rise at the sight of an equation. This is a factor one has to constantly keep in mind while trying to explain landforms through our limited understanding of geomorphologic processes.

It is possible, however, that the shortcomings of this book, i.e., the terse and often unrigorous presentation and the fluctuating expectations about the scholarship and ability of the reader, are inherent in the pursuit of the goal of providing a detailed and comprehensive text that deals with all the major geomorphologic processes within about 400 pages. This raises two important questions about the teaching of geomorphology: Is it possible, for example, to provide a student with the necessary exposure to the nature of open channel flow in an early chapter in a textbook in geomorphology at this level, or should the student spend more time and effort with a normal textbook, like the one by Henderson? Second, given the recent advances in the subject, is it possible to produce a comprehensive, readable text that covers all the different geomorphologic processes and yet still keep the book within manageable proportions? The success of *Process in Geomorphology* may very well be in making us more aware of the wealth of process-oriented studies in the last few years and also of the shortcomings in the education of student geomorphologists, but it is only partially successful in satisfying the need for a detailed and comprehensive process-oriented text in geomorphology.

Avijit Gupta is with the Department of Geography at the National University of Singapore.

Environmental Quality and Residuals Management

A. V. Kneese and B. T. Bower, The Johns Hopkins University Press, Baltimore, xiv + 337 pp., 1979, $25.00.

Reviewed by Robert Nelson

For almost 30 years now Resources for the Future (RFF) has been the leading research institute for natural resource policies. In this book, Allen Kneese and Blair Bower give an overview of the results of an environmental program begun at RFF in 1965.

RFF adopted an economic approach to environmental problems. From this perspective, pollution results from a market failure in that polluters do not have to pay for the damages from pollution—the 'external costs'—they impose on others. In essence the environment becomes a public commons in which there is no reason for polluters to exercise restraint. If this much is accepted, the solution is to require that pollution costs be internalized, either by a pollution tax or by requiring polluters to purchase pollution rights in a market. RFF has mainly put its eggs in the pollution tax basket. Over the past decade, its studies have contributed significantly to making the tax approach widely known and respectable.

Another important contribution of the RFF program has been to emphasize that there are many ways of achieving cost efficiency in reducing pollution. Redesigning the basic product, employing different production inputs, revising the manufacturing process, or other innovative approaches may well be the most efficient. For example, simply by changing from white to darker, unbleached paper, liquid pollutants may be reduced by 85% to 90% in paper production. The RFF environmental program undertook specific studies of the pulp and paper, petroleum refining, steel, automotive steel scrap, and coal-electric industries to demonstrate how a wide range of alternatives usually exist.

Another main theme of the RFF studies is the need to recognize the interrelationships among different types of pollution. Scrubbers, for example, limit air emissions but at the same time create a solids problem in disposing of sludge. Existing regulatory policies too often address air, water, and solids problems individually. The complexity of the pollution problem is shown in the development by RFF of a full-scale model for the Lower Delaware Valley region.

The last part of the book addresses the overall costs of pollution management. National expenditures in the early 1980's of $50 to $100 billion per year are estimated. As much as 25% of increases in national income in these years could be required for this purpose. The magnitude of these expenditures emphasizes the importance of achieving maximum cost effectiveness and also inevitably raises the question of how the benefits received compare with the costs.

The studies of the RFF environmental program have been a major contribution in the environmental field. Yet, its ideas have, perhaps, had a better reception among researchers and scholars than they have had impact on government policies. Unfortunately, the book does not consider the practical influence of the RFF studies. In fact it offers only passing mention of actual government regulations and the real world formulation of environmental policies.

The RFF program developed many of its arguments through some elaborate models. This may have been a mistake. Although RFF modeled several industries, the models were not sufficiently complete that they could be used to represent the actual circumstances of the industries. Their purpose was considered to be 'illustrative' of pollution reduction alternatives. The model is, in effect, an expository device.

An alternative method of exposition would have been to examine recent environmental legislation and agency administration and show a number of actual instances of inefficient pollution controls. By using concrete examples from actual experiences, government policy makers might have been forced to take greater notice. RFF might have been pushed into some major political controversies, might have appeared less scientifically neutral, and been exposed to more criticism, but that may be a necessary price for reaching a bigger and more influential audience.

RFF clearly recognized that political considerations often played a dominant role in determining environmental policies. It even undertook a major study of the politics of pollution control. But this study is probably the least satisfactory part of the RFF program. A high technical sophistication and substantial modeling effort went into reaching rather obvious conclusions, such as that there exist important 'opportunities for vote trading.'

In examining pollution control problems in the Lower Delaware Valley region, RFF's model once again proves to be merely illustrative. As a pedagogical device, large models are expensive and time consuming and have the further drawback that for most of the audience they require placing great trust in the model builder. In a somewhat skeptical age, policy makers prefer, if possible, to keep things simple enough that they can judge for themselves.

Until not so long ago, separate fields of economics and politics did not exist—only a single field of political economy. The RFF program of environmental studies probably would have benefitted from a much greater dose of political economy. This would have included paying much greater attention to institutional questions. The real key to improved environmental policies lies in devising solutions that existing institutions will accept. Compared to these problems, developing better technical models is a less challenging task.

Robert Nelson is with the Office of Policy Analysis of the U.S. Department of the Interior in Washington, D.C.

Earthlike Planets; Surfaces of Mercury, Venus, Earth, Moon, and Mars

Bruce Murray, Michael C. Malin, and Ronald Greeley. W. H. Freeman and Company, San Francisco, $24.95 hardbound, $14.95 paperback.

Reviewed by Harold Masursky

A quotation from the preface of the book sums up the authors' purpose in writing it:

> Traditional explanations of the nature and history of Earth and the other rocky, Earthlike planets of the inner Solar System—Moon, Mars, Venus, and Mercury—are crumbling under the impact of close-up and direct observations of actual surface phenomena. New insights are developing that link Earth, including the very atoms that compose its sentient beings, with the origin and evolution of those other four planets of the inner Solar System. . . . The book should be suitable as a supplementary text in college geology and astronomy courses and also of use in specialized courses covering topics in physical geology, geomorphology, planetary astronomy, volcanology, and planetary science.

In this text the authors discuss at length the comparative planetology of the terrestrial planets; that is, they describe and analyze the several planets that have been explored to date. Discussions of the moon, Mercury, Mars, and Venus are grouped under several headings: the global view; modifications by external processes (including impact, wind, water, and gravity effects); renewal by internal processes, including volcanism and tectonism; lengthy discussions are given for the moon, Mercury, and Mars, and in a final chapter on comparative planetology a short section is included on the moons of Jupiter. The book is illustrated by many photographs; some diagrams that show lunar cross sections, chemical groupings and ages of rocks; and a few colored illustrations of the surfaces of Mars and the Galilean satellites.

This book provides more thorough discussion of its subject matter than does Elbert King's *Space Geology* or J. E. Guest's atlas, *Planetary Geology*. It does not include as much comprehensive detail as is found in T. Mutch's *Geology of the Moon* or *Geology of Mars*, nor does it have the gloss, the abundant lovely color illustrations, or the creative authenticity provided by the scientist-authors of a newly published book, *The Solar System*, edited by J. K. Beatty and others. The discussion on Mercurian astronomical aspects, particles and field studies, and cratering is nicely done. The wind discussion is well done also. Perhaps Murray's involvement with Mercury and Greeley's with wind experiments account for the high quality of these discussions.

There is considerable discussion of volcanism on Mercury (where there is no overt evidence), of mare basalts on the moon, and of tectonism and volcanism on Mars, where the record is more varied. The lava plains of Mars as well as the great shield volcanos are covered. An account of silicic volcanism and its origin includes an explicit statement that silicic volcanism on the earth is usually a by-product of plate tectonics. However the highly feldspathic character of the moon's early crust indicates to some investigators that other fundamental processes, such as "magma oceans," may have generated highly feldspathic rocks on the moon. This subject is causing much ferment—witness Anderson's recent announcement of possible early magma oceans on the earth also. If uncertainties such as this had been better delineated, they would have made the reader more excited about these fundamental problems.

Conversely, the discussion of Martian channels is not sharply drawn. It seems to me that the authors suggest that there are various vaguely formed hypotheses for channel formation, none of which fits very well. Present hypotheses for channel formation by water, wind, ice, or tectonics have been delineated in considerable detail. It would be better to pose this question more clearly and perhaps suggest how the answer could be obtained by future investigations or additional space flights. For example, if channelling episodes could be dated, it might indicate whether both Earth and Mars glacial and interglacial epochs are due to variations in solar output, variations in orbital elements, or the heat engine of each body. Here again I missed the challenge inherent in this active frontier.

In many sections this book does not present the wide range of alternative hypotheses that are now being discussed. The reader is thus deprived of an awareness of the controversy inherent in present-day space exploration. Many subjects are still only tentatively explained, and many critical observations are yet to be made. The discussions could be expanded profitably to convey both the present sense of excitement of discovery and the rapid progress that is presently in full flower.

The book is small but reasonably priced. At present there is no other comparable alternative text available that presents as comprehensive a view of the interrelations of the solid planets. Inclusion of new data available from the Venus Pioneer spacecraft and from multifaceted views of the highly varied satellites of Jupiter and Saturn would provide a more broadly based text, which is urgently needed.

Harold Masursky is with the U.S. Geological Survey in Flagstaff, Arizona.

Chemical Equilibria in Soils

W. L. Lindsay, John Wiley, New York, xix + 449 pp., 1979.

Reviewed by D. Kirk Nordstrom

Lindsay's objective 'is to bridge the gap between soil science and chemistry and to show that most reactions taking place in soils can be understood and predicted from basic chemical relationships.' To achieve this objective he has written a book that simply describes the construction of nearly 100 mineral solubility diagrams and several aqueous distribution diagrams whose relevance to real soils is left as an exercise for the reader (both literally and figuratively). If you are looking for anything else that might fall under this title then you won't find it. Adsorption, colloidal processes, ion exchange, and other surface effects are not considered.

Following two introductory chapters on aqueous chemical equilibria, each chapter is assigned to an element or constituent type, such as aluminosilicate minerals (chap. 5), carbonate equilibria (chap. 6), phosphates (chap. 12), chelate equilibria (chap. 15), and organic transformations (chap. 23). The other element chapters are all organized in a similar fashion: solubility of oxides and hydroxides, silicate solubility, hydrolysis, complexes and redox for aluminum (chap. 3); silica (chap. 4); calcium (chap. 7); magnesium (chap. 8); sodium and potassium (chap. 9); iron (chap. 10); manganese (chap. 11); zinc (chap. 13); copper (chap. 14); nitrogen (chap. 16); sulfur (chap. 17); silver (chap. 18); cadmium (chap. 19); lead (chap. 20); mercury (chap. 21); and molybdenum (chap. 22).

Although this book's central theme is the diagrammatic representation of soil mineral solubilities, the classical use of solubility as the sum of all species is never represented. For example, the well-known parabolic *p*H-dependent curve for gibbsite solubility never appears. Instead, gibbsite solubility is shown as a linear *p*H function in terms of free aluminum ion only. This simplified approach is consistently used throughout the book.

The old and useless concept of *r*H (circa 1923) has been born again in a single-term expression called *pe* + *p*H by Lindsay to define the redox state of soil systems. This expression assumes that only one hydrogen ion is stoichiometrically associated with one electron per redox reaction, and any additional hydrogens are independent acid-base reactions. There is no demonstrable basis for this arbitrary rearrangement of the Nernst equation, and it leads to the confusing situation of treating *p*H as both a constant and a variable in the same reaction. This occurs in the chapter on sulfur, for example. It is unfortunate that *pe* + *p*H has been developed as a main feature of the book, since it is neither new nor useful.

The solubility, redox, and distribution diagrams are all based on a very extensive tabulation of thermodynamic data compiled by M. Sadiq and W. Lindsay. This carefully compiled reference is a valuable asset of the book except for several errors occurring in it, such as (1) some free-energy values for neutral aqueous species turn out to be the values for the fully dissociated solute rather than the ion pair, triplet, etc.; (2) goethite is taken to be more stable than hematite, contrary to both field observation and reliable solubility studies; (3) several inorganic compounds that are not known to occur as minerals and have no known importance in soil chemistry are included in the solubility diagrams; and (4) the thermodynamic values are not critically selected or fully evaluated for several systems of interest to this reviewer. Nevertheless, the thermodynamic data are up to date (as of April 1978), extensive, and fully documented.

The strength of this book is the straightforward derivation of solubility diagrams from thermochemical data, and as such it would be useful as a teaching reference. The weakness of the book is the lack of real world applications and relevance. Students, for example, might be led to believe that minerals such as fayalite, wustite, forsterite, anorthite, and enstatite might be realistic solubility controls on soil water chemistry. Also the full complexity of heterogeneous soil systems with multiple simultaneous equilibria is not presented, and the effects of surface chemistry are absent. As a course textbook it has many shortcomings; but as a reference for teachers and researchers who are investigating mineral solubilities, it can be useful provided that the data base and the solubility diagrams are not accepted uncritically.

D. Kirk Nordstrom is with the Water Resources Division of the U.S. Geological Survey in Menlo Park, Calif.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the issue required.

Replies to ads with box numbers should be addressed to: Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

POSITIONS WANTED
Rates per line
1-5 times—$1.00, 6-11 times—$0.75, 12-26 times—$0.55

POSITIONS AVAILABLE
Rates per line
1-5 times—$2.00, 6-11 times—$1.60, 12-26 times—$1.40

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS
Rates per line
1-5 times—$2.50, 6-11 times—$1.95, 12-26 times—$1.75

STUDENT OPPORTUNITIES
For special rates, query Robin Little, 800-424-2488.

POSITIONS AVAILABLE

University of Utah: Faculty Positions. The Department of Geology and Geophysics invites applications for four tenure track positions at the assistant to associate professor level.

1) *Economic Geology.* The specific area of expertise is open, however, preference will be given to candidates whose research interests are in geological, geochemical, or petrological characteristics of metallic mineral deposits.
2) *Sedimentary geology.* Applicants should have research interests in modern or ancient sedimentary basins.
3) *Seismology.* Applicants with backgrounds and specialties in seismic reflection, seismic imaging or theoretical seismology will be given preference.
4) *Potential fields.* Geophysicist with specialty in potential theory including gravity and magnetics. (The closing date for this position is January 31, 1982).

A Ph.D. or equivalent is required. The vacancies are to be filled by September 1982; the closing date for applications for positions 1–3 is December 31, 1981. Applicants should submit a vita, transcripts, a letter describing his/her research teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

The University of Utah is an equal opportunity/affirmative action employer.

Faculty Positions. *Two Faculty Positions in Geology.* Tenure-track positions in geology, assistant professorship. Ph.D. preferred or equivalent experience. Fall 1982.

Petrologist-Mineralogist. Candidate must be able to teach introductory geology, mineralogy, petrology, geochemistry, and optical mineralogy-petrography.

Invertebrate Paleontologist-Soft-Rock Geologist. Candidate must be able to teach courses in invertebrate paleontology, micropaleontology, sedimentation, and historical geology. Additional expertise in recent marine environments highly desirable.

Applicants are expected to do research in their areas of expertise, and to lead students' field trips. Strong teaching and research commitments expected. Submit applications with resume and copies of transcripts, and have three letters of recommendations sent to the Chairperson, Department of Earth & Space Sciences, Indiana University-Purdue University at Fort Wayne, Fort Wayne, Indiana 46805.

Indiana University-Purdue University is an equal opportunity/affirmative action employer.

Research Associate/Theoretical Physical Oceanography. Applications are invited for two postdoctoral research associate positions in the School of Oceanography, Oregon State University. Applicants will conduct research in theoretical modelling and observational comparisons of ocean circulation. Ph.D. in mathematics or the physical sciences. Submit resume, brief statement of research interests and three references to: Dr. Pearn P. Niiler, School of Oceanography, Oregon State University, Corvallis, Oregon 97331. Closing date extended to 30 January 1982.

An Affirmative Action/Equal Opportunity Employer.

Positions in Oceanography/VIMS. The Virginia Institute of Marine Science (VIMS)/School of Marine Science invites applications for two state funded, oceanography research and teaching positions at the levels of Senior Marine Scientist. VIMS is a broad-based marine science establishment with a mission to provide sound and timely advice to executive agencies and the legislature and to conduct incisive research programs. The School of Marine Science offers M.A. and Ph.D. programs with a faculty of 66 and 139 graduate students.

HEAD, DEPARTMENT OF GEOLOGICAL OCEANOGRAPHY (#113)

Applicants are sought with research interests in estaurine sedimentary geochemistry, dynamics of cohesive sediment transport, or estaurine and coastal morphodynamics. For further information contact Dr. Robert Byrne (VIMS), 804-642-2111 (Ext. 173).

ESTUARINE AND COASTAL HYDRODYNAMICS (Position #204)

A physical oceanographer with a strong interest in interdisciplinary approaches to complex estuarine and continental shelf problems is desired. For further information contact Dr. Bruce Neilson (VIMS), 804-642-6131 (Ext. 244)

Candidates for both positions should have established research credentials and be dedicated to furthering the research and educational programs of the Institute. Demonstrated ability to generate extramural support is expected. Salary range is $24,972 to $34,107 and faculty rank is commensurate with qualifications.

Applicants should send a comprehensive curriculum vita, reprints, and at least three letters of recommendation by February 1, 1982, stating specific position of interest, to: Employment Manager, Personnel Office, College of Wm & Mary, Williamsburg, VA 23185.

An equal opportunity/affirmative action employer.

Physical Oceanographer. Royal Roads Military College expects to have a tenure track vacancy in Department of Physics effective 1 July 1982. Candidates should hold doctorate or near doctorate in physical oceanography preferably with experience in digital hardware and microcomputer applications. Appointment expected to be made at assistant professor level but salary and rank dependent on qualifications and experience. Relocation expenses can be provided. Duties include undergraduate teaching in physics and physical oceanography, and research in marine science. Applications should include complete dossier and names of three references and be sent to: Dr. E. S. Graham, Principal, Royal Roads Military College, FMO Victoria, B.C. VOS 1BO.

This competition is open to both men and women. Knowledge of English only is required. Only Canadian citizens or Landed Immigrants need apply.

Toute information relative à ce concours est disponible en français et peut être obtenue en écrivant à Dr. Graham.

POSTDOCTORAL POSITION IN MARINE CHEMISTRY

Woods Hole Oceanographic Institution invites applications for the position of Postdoctoral Investigator. This position is being offered for basic research on the chemistry of the particle flux in the ocean and on the chemistry of sediment-seawater interactions, with particular emphasis on the transport of trace metals and radionuclides. Preference will be given to applicants with training in radiochemistry, trace-element analysis, surface chemistry, or geochemical modeling. Send resume and names of three references to:

Personnel Manager
Box 54P

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, MA 02543
An equal opportunity employer M/F/H

Planetary Scientist. SUNY Stony Brook, The Department of Earth & Space Sciences, anticipates that a tenure track faculty position may become available for a PhD Planetary Scientist. Planetary Science within this department spans the range of planetary atmospheres, cosmochemistry, and planetary geophysics. The candidate should have a demonstrated record of accomplishment. The appointee is expected to pursue an active research effort and will be responsible for teaching courses at the undergraduate and graduate level.

Send vitae and names of 3 references to: Dr. Roger Knacke, Dept. of Earth & Space Sciences, SUNY Stony Brook, Stony Brook, NY 11794.

SUNY Stony Brook is an EO/AA employer. AK #229A.

Surficial Geology/Ground Water. Utah State University. Tenure track position starting spring quarter of 1982 or fall quarter of 1982. Ph.D. required. Rank and salary negotiable. Surficial geology with emphasis on geologic field studies and ground water with attention to both geologic and geohydrologic aspects. Emphasis on the arid West. Closing date November 30, 1981. USU is an affirmative action equal opportunity employer. Department of Geology (07), Utah State University, Logan, Utah 84322.

Oceanographic Modeler. Ocean Data Systems, Inc. is seeking an applications oriented scientist to develop/adapt wave, HN and oil spill models for application in the Middle East on large CYBER computers. Position is in Monterey. Experience in commercial applications of varied oceanographic modeled output would be advantageous. Salary commensurate with ability and experience. Liberal benefits. Send resume to Mr. C. R. Ward, Ocean Data Systems, Inc., 2400 Garden Road, Monterey CA 93940.

Iowa State University of Science and Technology/Department of Earth Sciences.

Applications are invited for two tenure track faculty positions. The rank for each is at the assistant or associate professor level, dependent upon qualifications. The successful applicants will be expected to develop strong research and graduate student programs. Teaching duties will include undergraduate and graduate courses in the areas of expertise.

Mineral Resources/Economic Geology: One position is in mineral resources/economic geology. An applied field orientation is preferred. Iowa State has established a Mining and Mineral Resources Research Institute and an interdepartmental minor in Mineral Resources in order to support and develop research and education in this area. In addition to the appointment in the Department of Earth Sciences there will be full opportunities to interact with these programs.

Geomorphology: The second position is in the general field of geomorphology. Additional expertise in an area related to geomorphology, such as groundwater, engineering geology or remote sensing is also desired. A person with an applied field orientation is being sought.

Each appointment will be on an academic year basis. Opportunities are available for summer teaching appointments. Salaries will be commensurate with qualifications. Application deadlines for both positions are February 15, 1982; later applications will be accepted if a position is not filled. Positions are both currently available and are expected to be filled no later than fall, 1982. For application information please write to:

Bert E. Nordlie
Department of Earth Sciences
253 Science I
Iowa State University
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

South Dakota School of Mines and Technology. Applications are invited for two positions in the Department of Geological Engineering. Both involve teaching at undergraduate and graduate levels, thesis direction and development of research.

Geological Engineering: specialty in rock or soil mechanics, site evaluation, geohydrology, petroleum/reservoir engineering or engineering seismology. Industrial design experience helpful. A Ph.D. in some area of engineering is preferred.

Ore Deposits: area of specialization is open. The successful applicant will work closely with the newly established Institute for the Study of Mineral Deposits. The Ph.D. is required.

The Department has an undergraduate enrollment of 170 majors and a graduate enrollment of 60. Field applications of geology and engineering are emphasized. Interested persons should send a resume and three letters of recommendation to: Alvis Lisenbee, Dept. of Geology/Geological Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701.

SDSM&T is an equal opportunity employer.

Oceanographer. GS-1360-12, Salary $28,245-$36,723. The Remote Sensing Branch of the Naval Ocean Research and Development Activity (NORDA) is seeking qualified applicants for the position of Oceanographer. Duties include: Serving as principal investigator for planning and organizing basic and applied scientific investigations of radio probing of the ocean surface, and interpreting the results of these investigations in terms of oceanographic parameters. Specific areas of investigation will include the detection and analysis of ocean fronts and eddies through the use of satellite-borne altimeters. Responding to Announcement No. 81-039, send a current SF-171 no later than 21 December 1981 to the Civilian Personnel Office (Code 140A), Naval Ocean Research and Development Activity, NSTL Station, MS 39529 or call 601-688-4641 for appropriate forms or additional information.

An EEO Employer.
U.S. Citizenship Required.

Chemical Oceanography. Research Assistant Professor. Initial appointment for one year with the possibility of extension or entry into tenure track position based on competitive search. Ph.D. in chemical oceanography or related field required. Candidate with experience in the analyses of nutrient elements, metals and/or radioactive nuclides in marine samples preferred. Successful candidate must initiate research program either independently or in cooperation with existing faculty members. Position available fall, 1982. Salary commensurate with experience. The Oceanography Department offers programs leading to the M.S. and Ph.D. degrees. Send resume and three letters of recommendation by February 15, 1982 to Dr. George Wong, Department of Oceanography, Old Dominion University, Norfolk, VA 23508.

An Affirmative Action/Equal Opportunity Employer.

Crustal Geophysics/Tectonophysics or Sedimentology. The Department of Geology at the University of Kansas is seeking applicants at the assistant professor level for a potential additional tenure track position that will begin in August, 1982 or January, 1983. The appointment will be made in either crustal geophysics, tectonophysics, structural geology, or in sedimentology. The area in which the appointment will be made will depend upon the qualifications of the applicant and departmental needs. Duties include teachng in our introductory, undergraduate major, and graduate courses; advising students; supervising graduate student theses and dissertations; conducting original research; and providing service through administrative and professional activities. Applicants must have Ph.D. in hand or expect to complete it by the end of the first year of employment at the University. Minimum salary at the assistant professor level will be $23,000, if the position is authorized.

Crustal Geophysics, Tectonophysics or Structural Geology. We will consider applicants from all fields of geophysics and structural geology who are interested in applying their expertise to understanding the structure and evolution of the earth's crust and who will complement the five existing geophysics faculty of the Department and the Kansas Geological Survey. The successful applicant will be expected to cooperate with current faculty in offering courses at the undergraduate and graduate level that cover geophysics, tectonics, or structural geology.

Sedimentology. We will consider applicants in any branch of sedimentology, but those with interests in studying carbonate rocks, diagenesis and sedimentary geochemistry, or the relationships of sedimentation and tectonics are preferred. The applicant will be expected to cooperate with present faculty in offering courses at the undergraduate and graduate levels that cover all aspects of the study of sedimentary rocks.

Persons who have responded to earlier advertisements this year for sedimentology and structural geology need not re-apply, but will be automatically considered. In the event top candidates are about equally qualified, preference will be given to applicants whose areas of interests will complement those of the other faculty or who will participate in the department's summer field geology teaching program.

Priority will be given to applicants whose files are complete by February 1, 1982. Applicants should send a letter of application, a resume (including publication list), transcripts of all college level work, and names of three references to:

Ernest E. Angino
Department of Geology
University of Kansas
Lawrence, Kansas 66045
Phone: (913) 864-3771

The letter of application should include a statement of current and planned research interests and of courses that the applicant feels qualified to teach.

An equal opportunity/affirmative action employer. Applications are sought from all qualified people regardless of race, religion, color, sex, disability, veteran status, national origin, age, or ancestry.

Research Associate/Theoretical Physical Oceanography. Applications invited for two postdoctoral research associate positions in the School of Oceanography, Oregon State University. Applicant will conduct research in theoretical modelling and observational comparisons of ocean circulation. Ph.D. in mathematics or the physical sciences. Submit resume, brief statement of research interests and three references by 1 January 1982 to Prof. Pearn P. Niiler, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.

An affirmative action/equal opportunity employer.

Faculty Position/ASU. The Department of Chemistry at Arizona State University invites applications for a possible tenure track position at the assistant professor level in one of the following areas: (1) Synthetic Solid State Chemistry; (2) Surface Chemistry; and (3) Atmospheric or Low-Temperature Geochemistry. Candidates should have demonstrated in their Ph.D. and/or postdoctoral work the ability to develop a vigorous and innovative research program in one or more of the above areas and have a commitment to instructional excellence. A resume, brief description of research plans, and three letters of recommendation should be sent to Professor William S. Glaunsinger, Chairman, Search Committee, Department of Chemistry, Arizona State University, Tempe, Arizona 85287.

EO/AA employer.

Structural Geologist/University of Wyoming. The University of Wyoming, Department of Geology and Geophysics seeks applicants for a tenure track appointment in structural geology expected to be available beginning fall semester 1982 or earlier. Duties will include teaching of undergraduate and graduate courses in structural geology, supervising MS and PhD theses, and research in structural geology. Appointment at assistant professor level is preferred, but applicants requesting appointment at higher rank will be considered. Salary open. Applicants must have PhD degree and be versed in quantitative theory as well as field applications or modern structural geology and regional tectonics.

Applicants should provide, by January 1, 1982, a resume, three letters of reference, and a letter of application including a statement of current research interests and courses which the applicant feels qualified to teach. Applications should be sent to:

Dr. Robert S. Houston/Head
Department of Geology and Geophysics
University of Wyoming
Laramie, Wyoming 82071-3006.

The University of Wyoming is an equal opportunity/affirmative action employer.

Princeton University/Water Resources Program, Department of Civil Engineering. Department of Civil Engineering invites applications for a tenure track, three-year appointment at the assistant professor rank beginning on or before September 1982. Responsibilities include graduate and undergraduate teaching in hydrology and water resources, and participation in research into either hydrological processes associated with infiltration and unsaturated flow or chemical processes and transport in the unsaturated zone. Candidate must have Ph.D. degree with demonstrated teaching ability and scholarship.

Submit resume and references to:

Eric F. Wood, Director
Water Resources Program
Department of Civil Engineering
Princeton University
Princeton, NJ 08544.

Princeton University is an affirmative action/equal opportunity employer.

Hydrology: Tenure Track Position at Assistant or Associate Professor Level. Candidate should be a specialist in some quantitative aspect of hydrology with demonstrated skills in formulating hydrologic models, and a background in transport phenomena. Academic or professional credentials at Ph.D. level required. Starting date negotiable but could be as early as August 1982. Resumes, etc., should be received by March 1, 1982. Interested persons should request job description from: Dr. E. S. Simpson, Chairman, Search Committee, Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona 85721.

Equal opportunity/affirmative action employer.

Research Associate/Electron Microprobe. The Electron Microscopy Center at Texas A&M University invites application for the position of Electron Microprobe Specialist. Applicants should possess a working knowledge of WDS and EDS spectrometers and accompanying computer and software programs and preferably have had experience in the Geological Sciences.

The primary duties of the position are to oversee and maintain (with the aid of service contracts) the electron microprobe and ancillary equipment and to assist in teaching graduate course laboratories dealing specifically with electron microprobe analysis. Salary will be up to $25,000/12 months.

Applicant should send supporting data and letters of recommendation to:

Dr. E. L. Thurston
Texas A&M University
Biological Sciences Building
College Station, Texas 77843

Texas A&M is an equal opportunity/affirmative action employer.

Structural Geology/University of Illinois at Champaign-Urbana. (Search reopened) The Geology Department is seeking a structural geologist for a tenure-track (assistant professor) faculty position. A Ph.D. is required. Salary open. The successful candidate will be expected to teach advanced undergraduate and graduate courses in structural geology and establish a research program. For equal consideration, applications, including the names of three referees, should be sent by February 1, 1982 to Dr. D. E. Anderson, Department of Geology, University of Illinois, 245 Natural History Building, 1301 West Green Street, Urbana, IL, 61801–2999, (217) 333-6713.

Position to be filled by September 19, 1982.

The University of Illinois is an affirmative action/equal opportunity employer.

Faculty Position in Geophysics/Structural Geology/Engineering Geology. The Department of Geological Sciences at Case Western Reserve University in Cleveland, Ohio is seeking candidates to fill an anticipated faculty position in the broadly defined areas of geophysics/structural geology/engineering geology. While field of specialization is open, the successful candidate will be charged with conducting the Department's teaching programs in geophysics at the graduate and undergraduate levels, in addition to carrying out a vigorous research program. Ample opportunities exist for research collaboration both within the Department of Geological Sciences and with faculty members in the School of Engineering.

Ph.D. or equivalent is required. Please submit applications, consisting of résumé, names of three references and a statement of research and teaching interests to:

Samuel M. Savin
Department of Geological Sciences
Case Western Reserve University
Cleveland, Ohio 44106.

Case Western Reserve University is an equal opportunity/affirmative action employer.

Seagoing Research Assistant in Physical Oceanography. Applications invited for a position in the School of Oceanography, Oregon State University. B.S. in physics or engineering. Must have sea-going experience, needs some familiarity with computers and electronic instruments. Must be able to assume position by 15 February 1982. Appointee will take responsibility for deployment of a water-structure profiler on a cruise in May-June 1982; will take responsibility for preparation, calibrations, work at sea, and preparation of the data report. Salary: $20,000/yr or more depending on experience. Submit application and names of three references by 25 December 1981 to: Douglas R. Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331.

An affirmative action/equal opportunity employer.

Postdoctoral Fellowship/Department of Oceanography, University of British Columbia. Available January 1, 1982 for studies of the mineralogy and geochemistry of deep ocean ferromanganese nodules and the relationships between nodules and their associated sediments. Salary $16,000. Send curriculum vitae, statement of research interests and names of three referees to: S. E. Calvert, Department of Oceanography, University of British Columbia, Vancouver, B.C., Canada V6T 1W5.

Petrologist-Economic Mineralogist/University of Oklahoma. Applications are invited for a tenure-track position, effective September 1, 1982 at the assistant professor level, in petrology and economic mineralogy. The successful applicant is expected to teach graduate courses in his/her specialty, to help teach undergraduate courses in mineralogy-optics-petrography, and to pursue an active research program. Consulting and interacting with mining companies are encouraged.

The University of Oklahoma has made a major commitment to diversify the program in the School of Geology & Geophysics. As a result five tenure-track positions are open for the fall of 1982. Six new faculty were added to the School in the fall of 1981 (bringing the total full-time faculty to 15), and an additional six positions will be available during 1983–1985. A new building that will house the School is in the design stage, and the successful applicant will participate in equipping it.

The Ph.D. degree is required for this position. Preference will be given to petrologists with a strong chemistry background and with a demonstrated interest in the economic geology of metallic and non-metallic mineral deposits. Qualified applicants should arrange to send transcripts of all college and university work, resume, statement of research interests, and three letters of reference to: Dr. Maryellen Cameron, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma, 73019. Deadline for applications is December 31, 1981. Faculty members from the School will be interviewing at the November G S A meeting in Cincinnati, Ohio, and at the December A.G.U. meeting in San Francisco, California.

The University of Oklahoma does not discriminate on the basis of race, or sex, and is an equal opportunity employer.

Seismologist/University of Utah. Search extended: the University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic reflection, seismic imaging, and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students. The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The geophysics component of the department has strong research and teaching programs in seismology, electrical and electromagnetic methods, thermal properties of the earth, and potential fields. Current research in seismology includes seismological and earthquake research utilizing a new PDP 11/70 computer with plotter and terminals; monitoring of the intermountain seismic belt by a 55 station telemetered network utilizing a new on-line PDP 11/34 computer; major experiments in seismic refraction profiling; investigations of seismic propagation from synthetic seismograms, application of inverse theory to seismology, seismic properties of volcanic systems and allied research in tectonophysics. The closing date for applications is December 31, 1981. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity/affirmative action employer.

Geophysical Fluid Dynamicist/Physical Oceanographer. Applications are solicited for a junior faculty position in ocean physics or dynamics to begin in the academic year 1982–83. Areas of interest to the Department include analytical, numerical and laboratory modeling of physical processes and phenomena in the sea.

Yale University is an equal opportunity/affirmative action employer and encourages women and members of minority groups to compete for this position.

Curriculum vitae, publications, and the names of three or more referees should be sent by 31 December 1981 to: Robert B. Gordon, Chairman, Department of Geology and Geophysics, P.O. Box 6666, New Haven, CT 06511.

SERVICES

EST SERVICES. Scientific Translations From Russian to English. Specializing in Hydrology, Water Resources, and the Earth Sciences: pure research, engineering, construction, systems analysis, mathematical modeling. Experienced, extensive academic training, 15 years professional experience as a geohydrologist. Donald J. Percious, 3219 Camino del Saguaro, Tucson, Arizona 85705 (602) 743-0863.

GEOTHERMAL DEPOSITS. If you are financing, planning, designing, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's geothermal-energy deposits. Includes production and reserves for areas and wells. Hardcover, 6 × 9 inches, 292 pages. Table of contents, drawings, index, references, 1976. $84. Tatsch Associates, 120 Thunder Road, Sudbury, MA 01776.

STUDENT OPPORTUNITIES

Graduate Research Assistantships. Environmental science at the Oregon Graduate Center. Atmospheric and aerosol physics research programs in theoretical modeling of anthropogenic effects on stratospheric ozone and global temperature and in development and utilization of real time instrumentation for sulfur and carbon aerosols. Degree program provides for intensive research experience and maximum student-faculty interaction. $7500 stipend with remission of fees and tuition available to qualified Ph.D. students. Write: Dr. Douglas F. Barofsky, Oregon Graduate Center, 19600 N.W. Walker Road, Beaverton, Oregon 97006.

Exxon Teaching Fellowship at University of Michigan-Geological Sciences. Applications are invited for a three-year fellowship in the PhD program, supported by the Exxon Education Foundation. Annual stipends will be $12,000, $13,500, and $15,000 for the first, second, and third years, respectively, with full waivers for tuition and fees. The successful applicant will be a person who, at the time of the award, intends to pursue a college teaching career, is extremely articulate and has a demonstrably high quantitative and verbal aptitude, and is a U.S. citizen permanent resident. Regular admission and financial support applications must be received before February 1, 1982 to be considered. An extensive background in geological and cognate sciences is desirable. Unsuccessful applicants for the Exxon Fellowship are still eligible for our regular financial support. For further details contact R. Van der Voo, Chairman, Department of Geological Sciences, University of Michigan, Ann Arbor 48109.

Graduate Research Assistantships in Physical Oceanography. Opportunities for graduate study with Research assistantship available for students interested in M.S. or Ph.D. programs. A summer program with stipend is open to college juniors. Write: Douglas Caldwell, School of Oceanography, Oregon State University, Corvallis, OR 97331.

Graduate Study in Oceanography Oceanographic Engineering. Research Assistantships and research fellowships are available for graduate study in Physical and Chemical Oceanography, Oceanographic Engineering, and Marine Geology and Geophysics leading to a Ph.D. or Sc.D. degree conferred jointly by the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology. The awards cover tuition and provide an average monthly taxfree stipend of $540 to $590. Research topics available to student reflect the interests of the more than 100 doctoral scientists and engineers at WHOI and the faculties of ten different departments at MIT.

The program encourages applications from students with an undergraduate degree in any of the natural sciences or engineering. For additional information please contact: The MIT-WHOI Joint Program in Oceanography Oceanographic Engineering at either: The Education Office, The Woods Hole Oceanographic Institution, Woods Hole, MA 02543, or Room 54-911, The Massachusetts Institute of Technology, Cambridge, MA 02139.

AGU

Sponsors of 1981 New Members

Three hundred and sixteen new members were elected between September 1 and November 15, 1981. The AGU members who sponsored them are listed below.

Five Members: Mary P. Anderson.

Four Members: Richard K. Cardwell, Tom Dickey, Brooks B. Ellwood, Bryan L. Isacks, Leonard F. Konikow, E. N. Lightfoot.

Three Members: Joshua D. Cocker, Harold H. Demarest, Jr., Charles C. Goodrich, Douglas H. Hammond, A. I. Johnson, Hiroo Kanamori, Robert C. Liebermann, S. W. Lohman, William R. Muehlberger, Robert M. Ragan, Ching-Sheng Wu.

Two Members: Thomas J. Ahrens, Ernst Bleuler, Philip E. Brown, Michael J. Carr, Curtis Allan Collins, Charles S. Cox, Joseph R. Curray, Zoltan A. Der, John G. Ferris, Robert J. Geller, John P. Greenhouse, Arnold M. Hanson, Mark H. Houck, Burton H. Jones, Peter K. Kitanidis, William H. K. Lee, Frederick K. Mack, Guy A. Meadows, Ivan I. Mueller, Alexandra Navrotsky, D. R. Nielsen, John S. Nisbet, G. Nolet, Umed S. Panu, Charles T. Prewitt, James A. Richardson, Peter Robinson, José D. Salas, Thomas Schmugge, Donald I. Siegel, Frank J. Spera, Alan Summy, Lawrence A. Taylor, Ta-liang Teng, Robert Thunell, G. H. Toebes, Urho A. Uotila, Kenneth L. Verosub, Donald J. Weidner, David E. Weissman, James A. Whitney, Douglas F. Williams, Jin Wu.

One Member: Katsuyuki Abé, Vincent J. Abreu, Kaz Adamowski, Judson L. Ahern, Moid U. Ahmad, L. T. Aldrich, E. C. Alexander, Ina B. Alterman, Gordon D. Anderson, Kei Anma, Raymond Arvidson, Maha Ashour-Abdalla, Barry Kean Atkinson, William Back, Ben B. Balsley, Alan R. Bandy, John M. Bane, Jr., Fernando J. A. S. Barriga, Gordon D. Bath, Michael L. Bender, Steven C. Bergman, Suzanne Beske-Diehl, Keith Beven, Douglas C. Biggs, Roger Bilham, John M. Bird, E. G. Bombolakis, William J. Borucki, Anthony J. Bowen, David S. Bowles, Rafael L. Bras, Garrett W. Brass, Anita C. Brenner, David A. Brooks, E. M. Brooks, Ronald L. Brooks, Robert A. Brown, Kenneth W. Bruland, Wilfried H. Brutsaert, Jon B. Bryan, James A. Burnett, Alan W. Burns, Harold L. Burstyn, James D. Byerlee, Michael H. Byrne.

George E. Caledonia, Robert F. Carlson, R. L. Cardvillano, Neville L. Carter, Anny Cazenave, Charles E. Chamberlin, Frank Chapelle, Alan O. Chave, Lawrence A. Chitwood, Gary R. Chirlin, Bhaskar Choudhury, B. A. Christensen, Mark J. Cintala, Hans Claassen, John W. Clough, Ernest D. Cobb, Jared Cohon, Barney J. Conrath, Richard L. Cooley, Lindrith Cordell, Charles C. Counselman III, Fokke Cruetzberg, Steven Kent Croft, James W. Crosby III, George W. Cry, Conleth Cunnane, Thomas B. Curlin, Robert A. Dalrymple, E. Julius Dasch, John M. Davison, G. F. Davies, Kenneth Davies, Peter K. Davies, Donn G. De Coursey, Margaret Lois Delaney, Jacques W. Delleur, Victor E. Delnore, David J. DeMaster, Jimmy F. Diehl, S. Lawrence Dingman, James C. I. Dodge, Julie M. Donnelly, Robert L. Du Bois, John P. Dugan, Robert A. Duncan, Jeremy Dunning.

Timothy E. Eastman, Donald H. Eckhardt, Oscar B. Eckhoff, Floyd C. Elder, Olav Eldholm, Martin Engi, Irene M. Engle, Terry Engelder, Charles Eriksen, Fred T. Erskine, C. Patrick Ervin, David S. Evans, Joseph Fainberg, J. J. Fawcett, Philip M. Fenn, Arthur A. Few, Jr., David E. Fields, Jerald S. Fifield, L. A. Fisk, Yu-Si Fok, Michael G. Foley, Donald W. Forsyth, Jeff P. Fox, Melvin Friedman, James P. Friend, E. O. Frind, John William Geissman, Lynn W. Gelhar, Christoph K. Goertz, Kenneth A. Goettel, Melvyn L. Goldstein, Richard G. Gordon, David Grason, Alex E. S. Green, Kenneth E. Green, E. W. Greenstadt, David Greenwalt, Raul Guerrero, Ronald C. Gularte, Thorsten L. Gunther, A. B. Gureghian, Robert James Gurney, M. Susan Gussenhoven.

Peter K. Haff, Janet A. Haggerty, Stephens Edward Haggerty, D. A. Haith, Francis R. Hall, James M. Hall, Bruce B. Hanshaw, David G. Harkrider, C. G. A. Harrison, George E. Hart, Norman Harthill, Richard H. Hawkins, Stanley P. Hayes, Paul B. Hays, James W. Head, Gary R. Hecox, David V. Heimberger, Janet S. Herman, Gregory F. Herzog, John D. Hewlett, Donald G. Hill, George R. Holdren, Jr., Joseph V. Hollweg, William T. Holser, Thomas E. Holzer, Gary M. Hoover, Yuan-Huang L. Hsu, Frank T. Huang, Ste-

phen P. Huestis, R. H. Hunter, Liaquat Husain, Tissa Illangasekare, Andrew P. Ingersoll, Dallas B. Jackson, Ian N. S. Jackson, Gary K. Jacobs, Ivan C. James II, J. Douglas James, Raymond Jeanloz, Ronald E. Johnson, Tracy L. Johnson, Blair F. Jones, Glyn M. Jones, Gieskes Jorism, Darrell L. Judge, Donna M. Jurdy.

Douglas L. Kane, Robert B. Kasper, Keith W. Katahara, Susumu Kato, George V. Keller, William W. Kellogg, B. L. N. Kennett, Iwane Kimura, Charles T. Kincaid, Fred W. Klein, Georges deVries Klein, Martin J. Koomen, A. Kroner, James L. Krumhansl, Roman Krzysztofowicz, Philip R. Kyle, John L. La Brecque, Gerard Lachapelle, L. Stephen Lau, Michael T. Ledbetter, Baum K. Lee, Tay-How Lee, Chin S. Lin, Donald H. Lindsley, John G. Liou, Richard Lively, Max Loewenstein, John M. Logan, Leland Timothy Long, Robert P. Lowell, Allen Lowrie, Charles A. Luther, Gregory A. Lyzenga.

William D. MacDonald, Peter K. MacKinnon, Syukuro Manabe, David H. Marks, Bruce D. Marsh, James G. Marsh, Margaret Elizabeth Marshall, George B. Matanga, Barry H. Mauk, Barbara B. Mavko, John C. Maxwell, Ted A. Maxwell, Hans G. Mayr, Samuel W. McCandless, Jr., William R. McCann, James S. McClain, Kenneth A. McGee, L. D. McGinnis, Christopher P. McKay, Karen C. McNally, A. G. McNamara, John K. McRaney, Harry Y. McSween, Jr., Judson Mead, W. D. Means, Scott G. Melford, R. Melfzner, Robert L. Melvin, Michael Mendillo, James W. Mercer, Gerald Meyer, Jean-Francois Minster, Polve Mirelle, Jerry L. Modisette, Harold O. Mofjeld, Volker A. Mohnen, Erik Mollo-Christensen, Judith B. Moody, Christopher N. K. Mooers, Michael M. Mooradian, Stearns A. Morse, Paul Morgan, Helmut Moritz, Sharon Mosher, Robert A. Muller, John J. Murray.

Kazuaki Nakamura, Manuel Nathenson, Kenneth H. Nealson, Shlomo P. Neuman, Carl A. Newton, V. V. Nguyen, Yasunori Nishida, Clyde Nishimura, Charles A. Nittrouer, James S. O'Brien, Richard J. O'Connell, Anne O'Donnell, Emile A. Okal, Julio C. Olimpio, John J. Olivero, Peter Olson, Michael L. Oristaglio, Peter J. Palmadesso, Donald F. Palmer, Hans A. Panofsky, K. Papadopoulos, George K. Parks, Mervyn S. Paterson, Malcolm R. Patterson, William C. Patzert, Adolf K. Paul, Rudolf Penndorf, Henry T. Perkins, Mary Jane Perry, Mark E. Pesses, John A. Philpotts, Richard E. Pieper, Nicklas G. Pisias, Philip D. Rabinowitz, Chandra S. Rai, Sundar Rajan, W. T. Rawlins, Walter J. Rawls, David K. Rea, George Reid, Stephen P. Reidel, Patricia Hofer Reiff, Bodo W. Reinisch, Stuart R. Remz, Richard Reynolds, J. Michael Rhodes, Jack M. Rice, Paul G. Richards, John B. Robertson, Pierre-Yves F. Robin, John Rodgers, Alice M. Rogan, William M. Roggenthen, John V. Ross, Kelly E. Rowe, John C. Rucklidge, John Rundle, Ernest Henry Rutter.

Neil E. Salisbury, Patricia F. Salter, Charles G. Sammis, David Sandwell, Jorge L. Sarmiento, Tetsuya Sato, Y. Sato, Kim D. Saunders, Edward William Sawyer, Jean-Guy Schilling, Stephen H. Schneider, Jeffrey P. Schubert, Frederick Roy Schult, James D. Schumacher, Margaret Ann Shea, Charles R. Shearer, Neil R. Sheeley, Jr., Alan Shiller, Kunihiko Shimazaki, Thomas H. Shipley, Peter N. Shive, Robert A. Shuchman, Kerry E. Sieh, Eli A. Silver, David W. Simpson, Vijay P. Singh, A. K. Sinha, Ogbazghi Sium, William L. Sjogren, Allan Skorpen, Don F. Smart, Eugene Smart, Christopher R. Smith, Sheldon Sommer, Bengt Sonnerup, D. J. Southwood, Warren T. Spaeth, Jr., P. Srinivasan, Robert J. Starmer, Charles F. Stayer, Heinz G. Stefan, Maureen Steiner, Yaron M. Sternberg, Edward F. Stoddard, Frank S. Stone, D. W. Strangway, Ronald Street, William D. Stuart, Brian W. Stump, Lynn R. Sykes.

Joern Thiede, Gary E. Thomas, George A. Thompson, Lonnie G. Thompson, John Thraikill, John Toole, Robert J. Tracy, Georges Vachaud, Janet Van der Veen, Gilbert K. Van Dyke III, Mario S. Vassiliou, William W. Vaughan, James F. Vedder, Richard Carl Vierbuchen, Jr., N. J. Visar, Marc Vuagnat, Hare S. Waff, R. J. Wagenet, Jean Jacques Wagner, Brian Wannamaker, Robert C. Ward, Richard Watt, Deborah J. Wechsler, Andrew J. Weinheimer, David B. Wenner, Frank J. Wentz, Daniel Wieder, Donald U. Wise, Peter M. Woiceshyn, Roger G. Wolff, David R. Wones, Eric Wood, Mark T. Woods, David A. Woolhiser, Marinus J. R. Wortel, Peter J. Wyllie, William Yeh, S. H. Yungul, Siavosh M. Zand, Alex Zaporozec, Victor Zlotnicki, Ernst G. Zurflueh.

Candidates Statements: Section Presidents-Elect

In the next few issues, comments from all candidates for office of section president-elect will appear. The statements for Geodesy, Geomagnetism and Paleomagnetism, Hydrology, and Solar-Planetary Relationships sections appear below.

B. D. Tapley (Geodesy)

The following subjects are of importance to the AGU at large and the geodetic community in particular:

1. A significant effort should be made to improve communication between the organizations involved in geodetic operations, which include both industries and federal agencies, and research activities associated with the development and initial exploitation of contemporary geodetic instruments and theoretical approaches to the use of the new data types (VLBI, laser, Global Positioning System, satellite altimetry, GRAVSAT, etc.). Efforts to stimulate the dialogue between the research and application communities will bring new techniques into the operations area at the earliest feasible time and will provide a proper stimulus for the research and development activities. Such dialogue should be enhanced through special sessions at the biannual AGU meetings and by sponsoring intersociety workshops and specialized symposiums.
2. The AGU should initiate an effort to evaluate and improve the university educational offering in the area of geodesy. A geodesy section sponsored by the Education Affairs Committee should be given the responsibility for developing plans for improving the quality of the educational programs in geodesy and geophysics.
3. The role of geodesy in other related areas should be identified and actions initiated to satisfy the geodetic requirements that emerge in these areas. Of particular significance are the roles that geodetic methods play in the areas of oceanography (definition of the geoid and gravity field and ocean surface and ocean bottom positioning) and seismology (precise point positioning, the time rates of change of point position, polar motion, etc.).
4. The roles of large data set collection, archiving, and dissemination are topics of major concern to the geodetic community. The Geodesy section activities, through the section meetings and/or technical committee, should seek to distribute information on the availability of data for geodetic studies, to define archival requirements for geodetic data base, and to identify requirements that are not being met by current agency actions.

If elected, I will work toward achieving the objectives outlined above.

Petr Vanicek (Geodesy)

North American geodesy has been suffering from a lack of identity. This continent has seen some of the most spectacular geodetic achievements; yet, often enough these were born under the auspices of space science, tectonophysics, oceanography, etc. Some of my more pragmatic colleagues will argue that there is nothing wrong with this 'throw out plurality.' I feel, however, that the cause of science would be better served if geodesy were, once more, recognized for what it is: a scientific discipline in its own right.

Geodesy is the discipline that concerns itself with the geometry of the earth and its gravity field, including the temporal variation thereof. Thus geodesy is as much a part of geophysics as geometry is a part of physics. It is on these philosophical foundations that the Geodesy Section should cooperate with the other sections of AGU. It is this position that the Geodesy Section should take when asking itself what is there that geodesy can do for the other disciplines and what is there that the other disciplines can do for geodesy. It is this point of view that I should adopt if elected to the presidency.

On a more down-to-earth level, the section may consider doing more for the promotion of AGU among professional colleagues and students alike. The promotion should include soliciting research papers as well as review papers for JGR and RGSP and soliciting manuscripts for publication in the *AGU Monograph Series*. As an example of other possibilities, the section may consider launching a campaign to evaluate geodetic content in various pertinent university programs on this continent and publish the results.

To end, I should like to thank the Nominations Committee for the honor they bestowed upon me by nominating me, even though I am not a United States citizen.

Christopher G. A. Harrison (Geomagnetism and Paleomagnetism)

The main function of the American Geophysical Union is to provide communication channels between geophysicists. This is done by the meetings and the publications programs of AGU. Actions taken at council meetings can affect both of these programs, and one of the jobs of council members is to ensure that the various programs remain effective. This is especially true during times of rapid change, which we are seeing today. For instance, the publications program of AGU is undergoing several changes that may affect members affiliated with the GP section. The Red JGR has had a significant increase in size under the editorship of Tom Ahrens, and a new journal, *Tectonics*, has been started in collaboration with the European Geophysical Society. The annual meetings are also undergoing change, with the western one, in particular, growing through the years. The increase in submitted abstracts may necessitate significant changes in the way the meetings are organized. In order that a council member may adequately represent his or her section members at council meetings, it is important that there be good communication between the council representative and the members of the section. The lunch meetings of the GP section, which take place at the annual meetings, provide some opportunity for exchange of ideas which I would like to see made greater use of. I shall also try and discuss issues with individuals during the annual meetings so as to be better prepared to represent GP at the council meetings.

Other things that are of importance to GP members are that magnetic observatories continue to operate, that new orbiting magnetic observatories be launched in a timely manner, and that our data bases at the National Data Centers be kept up-to-date.

Neil D. Opdyke (Geomagnetism and Paleomagnetism)

It is a great honor to be selected by the nominating committee to run for president of the GP section. It is my opinion that the section is doing quite well; however, there is one matter that must be addressed if we are to remain a coherent active group. The problem to which I am referring is the increasing tendency for the sections to split into a West Coast and an East Coast group based upon the respective national meetings. How this tendency can be countered during a time of increasing difficulty in obtaining additional funds for travel is difficult to see. A possible route may be to attempt to coordinate the symposium offered at the two meetings to have as wide an appeal as possible and to invite speakers to these symposium from both coasts. Therefore, if elected, I would attempt to be more involved in the coordination of the programs for the two meetings so as to maximize the interaction of what is rapidly becoming two constituencies.

R. Allan Freeze (Hydrology)

I believe that the Hydrology Section of AGU is currently in good hands, and I would not envisage any major shifts in direction should I be elected president of the section.

The primary obligations of the section's executive are to ensure efficiency and quality in the publications program and in conferences and symposia. On the publications side, our research journal, *Water Resources Research*, has a strong reputation, and I would provide the necessary support to the editors to ensure the continuation of this reputation.

One of the long-standing problems in the section is how to bridge the gap between the relatively small number of research-oriented hydrologists who tend to publish in WRR and the much larger number of practicing hydrologists who form the backbone of the section. The user-oriented publications of the *Water Resources Monograph Series* have the potential to be the primary vehicle for bridging the gap. I would like to see this program improved and expanded.

With respect to symposia, I would like to see continued expansion of the Chapman Conference program. All the Chapman Conferences to date have been successful and well attended. Recent annual meetings, despite excellent technical sessions, have experienced relatively poor attendance. This problem deserves continued attention.

I understand that the technical committee structure in the section is healthy and active. I hope to see the members of these committees play a leadership role in the development of Chapman Conferences and in the organization of technical sessions at the annual meetings. In particular, I would like to see more technical sessions that cross the interdisciplinary boundaries within hydrology.

On a broader front, I would like to see greater interaction between the Hydrology Section and the other sections of AGU. I think we should abandon our traditional role as outsiders and jump headlong and headstrong into AGU affairs, both political and scientific. In the long haul, I believe that this is the best way to project the interests of the Hydrology Section within AGU and throughout the broader scientific community.

George C. Reid (Solar-Planetary Relationships)

The disciplines represented by the Solar-Planetary Relationships Section of AGU are facing a period of crisis brought about by the proposed major decreases in research funding. They are likely to be affected to an even greater degree than other areas of basic science, since they have become so dependent on spacecraft missions whose future is, to say the least, unpromising. In this situation, a slight shift in the emphasis of AGU might be worth considering. Traditionally, AGU has not played an active 'lobbying' role, restricting itself mainly to the development of communication among scientists through the twin media of publications and meetings. This should certainly continue to be its principal function, but I should like to propose an increase in emphasis on communication between scientists and the outside world. The market for popular science is stronger than ever before among the educated public, and Solar-Planetary Relationships has an interesting story to tell. I feel that our section should work, through its officers, with the Public Affairs Committee of AGU to convey the inherently exciting aspects of our work to the general public and thereby start to build an effective lobbying force among the public, most of whom are not aware of the serious dangers that the future holds for science.

There are a few specific issues facing both the Union and the section that will demand attention in the near future. The proposal that the Aeronomy subsection be merged with the Meteorology Section to form an Atmospheric Science Section is probably the one of most direct and immediate concern. While this proposal has obvious merits, there are potential problems that need to be examined and laid to rest before a final decision is made. Some restructuring within the section may also become desirable, whether or not Aeronomy remains as part of SPR.

The AGU journals represent a valuable international resource and are among the world's leading journals in their fields. This is especially true of blue JGR, relative to the disciplines of SPR, and every effort should be made to maintain, or even to enhance, its position. If elected, I propose to work with the Editor, the Publications Committee, and the Council to support the cause of blue JGR and to avoid any changes that may be detrimental to its unique international standing. The problem of journal finances is likely to increase in importance in the next few years, and the long-standing question of the balance between individual and institutional subscription rates may need reexamination. In these issues, and in others as they arise, I shall try to act in the best interests of the section, of the Union, and of the discipline itself.

Christopher T. Russell (Solar-Planetary Relationships)

The primary function of the AGU is and should continue to be scientific communication. The AGU fosters this communication in many ways: through its weekly newspaper, *Eos*; through its research journals, review journals, and books; and through its sponsorship of annual meetings and Chapman Conferences. Three aspects of the journals program are of most concern to the membership: editorial quality of content, cost, and timely publication. I am quite satisfied with the editorial content of the AGU journals. In the SPR section the journals of choice are the JGR and GRL. However, I am not satisfied with the length of the time from submittal to publication for JGR and to a lesser extent for GRL. The decline in subscriptions alarms me. The more AGU journals are in scientists' offices, the more the articles within them will be used. Perhaps subscription rates need to be decreased at the expense of page charges.

In the area of the annual meetings the AGU seems to be choking on its success. Is there a reasonable solution to the problem of overcrowded rooms and conflicting parallel sessions? I believe we should analyze carefully why this crowding has come about before offering solutions. I do not believe poster sessions are the instant cure-all to the problem, nor is the arbitrary rejection of abstracts desirable. I entered the field too short a time ago to believe the 'old boys' know what should be accepted. We must nurture new blood and innovation. The Chapman Conferences have proven themselves to be effective and provide an atmosphere unattainable at the annual meetings. However, have we used them most effectively? Have the subdisciplines in SPR had their fair share of these conferences? I believe that the SPR section officers should take a more active role in promoting Chapman Conferences to cover the needs of the members.

We should not overlook the other roles of the AGU, even though they do not touch us as directly or as often as meetings. We must encourage good young people to enter the field, even with the uncertain job market. There will always be a need for good people in our field. At the present time the employment opportunities in the various sections of geophysics is uneven. The AGU can assist in smoothing this imbalance by matching prospective employees with available geophysicists when they find themselves outside the 'old boys network' in a particular area. Finally, we live in changing times. The amount of money available for research seems to be going down. The attitude of the federal government regarding the need for basic research seems to be taking a turn for the worse. At a very minimum we need the AGU to act as a listening post for us and to keep the membership informed about the issues that affect geophysicists. However, perhaps the time has come when the AGU and its members should take a more active role in informing the general public and those in the federal government about what we do.

One last point that has concerned me over the years is the rate of errors in the membership service area: lost subscriptions, lost articles, and the like. There has been much improvement over the last year, but there is still room for further improvement, and as a council member I would continue to monitor this area and assist in promoting a mistake-resistant system at AGU headquarters.

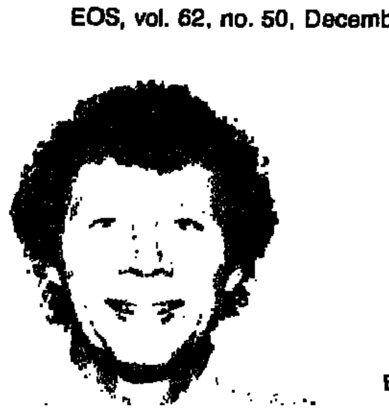
BALLOT CHANGES

Withdrawn

Donald R. Nielson has withdrawn as a candidate for president of the Hydrology Section.

Petition Candidate

Joseph N. Barfield has been approved as an additional candidate for Secretary of Magnetospheric Physics for the Solar-Planetary Relations Section. His biography and picture appear below.



Barfield

Age 40; he has been a member of the AGU since 1968. He is a staff scientist with Southwest Research Institute in San Antonio, Texas. His research interests include magnetospheric substorm dynamics, magnetospheric current systems, and ULF waves in the magnetosphere. He earned his B.A. in physics from Rice University in 1965 and his Ph.D. in planetary and space physics from UCLA in 1972. He was a research physicist with the NOAA Space Environment Laboratory from 1972 to 1979, where he participated in the analysis of Explorer 45 particle data and was responsible for processing of the NOAA magnetometer data bases. Instrumental in the planning of the North American IMS magnetometer data base, he was the IMS data coordinator for NOAA SEL. After 2 years as an independent consultant, he joined Southwest Research Institute, where he has continued his magnetic-field research and has participated in the design of the data processing system for the Dynamics Explorer space plasma data. He has authored or coauthored 29 scientific articles, including 17 in AGU publications. He has served as referee for various journals and as organizer for two international scientific conferences. He has also served as session chairman at several AGU meetings and as an invited speaker at several international symposia. Barfield is presently a member of the National Academy of Sciences Panel on the International Magnetospheric Study (Data Analysis Phase) and is a member of a number of working groups in space physics.

Meetings

Aerospace Sciences Meeting

The American Institute of Aeronautics and Astronautics' 20th Aerospace Sciences Meeting, to be held in Orlando, Fla., on January 11–14, 1982, will include four main sessions and a special presentation by Esker Davis, Voyager project manager, entitled 'Voyager: A Parade of Giants.'

Results from the Spacecraft Charging at High Altitude (SCATHA) program will be summarized in one session. For more information, contact A. L. Vampola, The Aerospace Corp., P.O. Box 92957, Los Angeles, CA 90009. Seven papers will describe the science and engineering of a proposed space mission in a session entitled 'Star Probe: A Mission to the Sun.' For additional information, contact D. Sonnabend, Jet Propulsion Laboratory, Pasadena, CA 91103. 'Active Space Experiments' will include six papers on the results of active stimulation of space plasmas. Details can be obtained from S. Kaye, Plasma Physics Laboratory, Princeton University, Princeton, NJ 08544. Six papers will evaluate the effects of the environment of space on spacecraft systems. For additional information, contact C. P. Pike, Air Force Geophysics Laboratory, Hanscom AFB, MA 01731.

General information about the meeting can be obtained from Paul F. Mizera, The Aerospace Corp., P.O. Box 92957, Los Angeles, CA 90009 (telephone: 213-648-6514).

Water: Indiana's Abundant Resource

A call for papers has been issued for the Third Annual Indiana Water Resources Symposium, sponsored by the Indiana Water Resources Association. Papers are invited on all aspects of water resources, but special emphasis will be placed on papers addressing irrigation, urban hydrology, water quality, groundwater hydrology, lakes and wetlands hydrology, hazardous wastes, or multipurpose water uses.

For a paper to be considered for the meeting, which is scheduled for June 9–11, 1982, in South Bend, Ind., authors should submit an original and four copies of detailed abstracts of their papers no later than January 8 to John E Fisher, Chairman, Third Annual Indiana Water Resources Symposium, Lawson-Fisher Associates, 525 West Washington St., South Bend, IN 46601 (telephone: 219-234-3167). Abstracts should not exceed 250 words and are to include the paper title, author name(s), affiliation(s), address(es), and telephone number(s). The senior author should be noted with an asterisk. Authors will be notified at the end of January. Camera-ready copy must be submitted by April 1.

Organizations wishing to present an exhibit at the symposium also should contact Fisher by January 8.

Paleoenvironment of East Asia

The Centre of Asian Studies at the University of Hong Kong is proposing to convene a conference in early December 1982 on the Paleoenvironment of East Asia from the Mid-Tertiary. The conference objective will be to review the evidence for the sequence of geology and paleoclimatology that parallel evolution of biological ecosystems in Asia. This review should lead to a definition of the nature of the environment in which hominids and early forms of *Homo* evolved in east Asia, according to the centre.

Geologists, geomorphologists, paleooceanographers, paleometeorologists, paleoclimatologists, paleoecologists, paleozoologists, and paleoanthropologists are expected to contribute to the conference. In addition, specialists from China, Japan, Korea, and Taiwan are expected to describe their advances in these disciplines.

Those wishing to participate should contact, by March 31, Edward K. Y. Chen, Director, Centre of Asian Studies, University of Hong Kong, Hong Kong. Statements of intention to attend and offers of papers (with 200-word abstracts) to be presented in English are welcome.

Geophysical Year New Listings

(Boldface indicates meetings sponsored or cosponsored by AGU.)

1981

Dec. 18–19 Annual International Meeting of the Working Group on Mediterranean Ophiolites, Florence, Italy. (Luigi Beccaluva, Istituto di Petrografia, Via Gramsci 9, 43100 Parma, Italy.)

1982

Jan. 3–8 Annual Meeting of the American Association for the Advancement of Science, Washington, D.C. (AAAS Meetings Office, 1776 Massachusetts Avenue, N.W., Washington, DC 20036.)

Jan. 11–14 Symposium on the Understanding of Hydrologic Processes at the Basin Scale, Caracas, Venezuela. Sponsors, Universidad Simón Bolívar, IAHS. (Ignacio Rodríguez-Iturbe, Universidad Simón Bolívar, Apartado Postal 80.659, Caracas 1081, Venezuela.)

Jan. 13–15 National Radio Science Meeting, Boulder, Colo. Sponsors, U.S. National Committee for the International Union of Radio Science, IEEE. (U.S. National Committee for URSI, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC 20418.)

Jan 24–29 **Conference on Origins of Plasmas and Electric Fields in the Magnetosphere,** Yosemite National Park, Calif. Sponsors, NASA, AGU. (F. T. Berkey, Center for Atmospheric and Space Sciences, Utah State University, UMC 34, Logan, UT 84322.)

January 26–29 Fourth Annual Conference on the NASA Geodynamics Program, Greenbelt, Md. (P. T. Taylor, Code 922, NASA/Goddard Space Flight Center, Greenbelt, MD 20771.)

Feb. 8–12 **Third International Geodetic Symposium on Satellite Doppler Positioning,** Las Cruces, N. Mex. Sponsors, Defense Mapping Agency, National Ocean Survey, AGU. (Richard Peat, Defense Mapping Agency, Hydrographic/Topographic Center, 6500 Brooks Lane, N.W., Washington, DC 20315.)

Feb. 16–19 **Ocean Sciences: AGU/ASLO (American Society of Limnology and Oceanography) Joint Meeting,** San Antonio, Tex. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

Feb. 25–26 13th Annual Meeting of the International Erosion Control Association, Salt Lake City, Utah. (M. McMillan, Erosion Control Consultants, P.O. Box 195, Pinole, CA 94564.)

Mar. 22–26 International Symposium on Hydrothermal Reactions, Yokohama, Japan. Sponsor, Tokyo Institute of Technology. (Shigeyuki Sōmiya, Research Laboratory of Engineering Materials, Tokyo Institute of Technology, Nagatsuta, Midori, Yokohama, 227 Japan.)

Mar. 24–27 Conference on Earthquake Hazards in the Eastern San Francisco Bay Area, Hayward, Calif. Sponsors, USGS, East Bay Council on Surveying and Mapping, Calif. Div. of Mines and Geol., Woodward-Clyde Consultants, Calif. St. Univ. at Hayward. (Sue Hirschfeld, Dept. of Geological Sciences, California State University, Hayward, CA 94542.)

Apr. 11–16 Penrose Conference on Antarctica, Shenandoah National Park, Va. Sponsor, GSA. (Ian W. D. Dalziel, Lamont-Doherty Geological Observatory, Columbia University, Palisades, NY 10964.)

April 19–21 Cordilleran Section, Geological Society of America and Seismological Society of America Annual Meeting, Anaheim, Calif. (Neil Maloney, Earth Science Department, California State Univ., Fullerton, CA 92634.)

April 27–29 **Chapman Conference on Rainfall Rates,** Urbana, Ill. (Meetings, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.)

May 3–6 **Chapman Conference on the Discontinuities in Rock: Their Role and Significance in Geologic Processes,** Santa Fe, N. Mex. (Meetings, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.)

May 3–7 **14th International Liège Colloquium on Hydrodynamics of Equatorial Oceans,** Liège, Belgium. Sponsors IAPSO, Unesco Marine Sciences Division, EGS, Intergovernmental Oceanographic, AGU. (Jacques C. J. Nihoul, University of Liège, Mécanique des Fluides Géophysiques-Environment, B6- Sart Tilman, B-4000 Liège, Belgium.)

May 7–20 General Meeting of IAG, Tokyo, Japan (I. Nakagawa, Geophysical Institute, Kyoto University, Sakyo-ku, Kyoto 606 Japan.)

May 10–12 Annual Meeting of the Canadian Geophysical Union, Downsview, Ontario, Canada. (D. E. Smylie, Department of Physics, York University, Downsview, Ontario, Canada M3J 1P3.)

May 10–12 Fourth International Conference on Planning and Management of Water Resources for Industrial, Agricultural, and Urban Use, Marseilles, France. Sponsors, Commission Européenne Méditerranéenne de Planification des Eaux (C.E.M.P.E.), Société des Eaux de Marseille (S.E.M.), the Bureau de Recherches Géologiques et Minières (B.R.G.M.), Centre de Formation Internationale à la Gestion des Resources en Eau (CEFIGRE), UNESCO, Commission des Communautés Européennes, Association des Hydrogéologues (AIH). (Secretariat de la Conference, Societe des Eaux de Marseille, 25 rue Edouard Delanglade—13006 Marseille, France.)

May 12–19 IASPEI/UNESCO Workshop on the Theory, Observations, and Causes of Seismic Anisotropy, Suzdal, USSR. (E. M. Chesnokov, Institute of Physics of the Earth, Bolshaya Grouzinskaya 10, Moscow 123810, USSR.)

May 17–22 Fifth International Symposium on Solar-Terrestrial Physics, Ottawa, Ontario, Canada. Sponsors, SCOSTEP, COSPAR, IAGA, URSI, IUPAP. (J. G. Roederer, Geophysical Institute, University of Alaska, Fairbanks, AK 99701.)

May 17–22 Symposium on Remote Sensing and Mineral Exploration, Ottawa, Ontario, Canada. Sponsor, Committee on Space Research (COSPAR) of the International Committee of Scientific Unions (ICSU). (W. D. Carter, EROS Office, U S G.S. (MS 730), Reston, VA 22092.)

May 17–June 3 24th Plenary Meeting of COSPAR, Ottawa, Ontario, Canada. (T. W. McGrath, Executive Member, Local Organizing Committee, XXIV COSPAR, Conference Secretariat, National Research Council, Ottawa, Ontario K1A OR6, Canada.)

May 23–26 Eastern Conference on Water and Energy, Technical and Policy Issues, Pittsburgh, Pa. Sponsors, ASCE, League of Women Voters, Council of State Governments (F. Kilpatrick, USGS National Center, Mail Stop 414, Reston, VA 22092.)

May 23–27 Second International Conference on Geological Information, Golden, Colo. Sponsors, Geoscience Information Society, Geological Information Group of the Geological Society of London, International Union of Geological Sciences, Association of Chief Librarians of National Geological Surveys, Association of Geoscientists for International Development. (D. C. Ward, International Conference on Geological Information, 223 Natural History Building, 1301 West Green Street, Urbana, IL 61801.)

May 23–28 Penrose Conference on Tectonic History of the Ouachita Orogen, Arkadelphia, Ark. Sponsor, GSA. (W. A. Thomas, Department of Geology, University of Alabama, University, AL 35486.)

May 24–28 Joint International IEEE/APS Symposium, National Radio Science Meeting, and Nuclear Electromagnetic Pulse Meeting, Albuquerque, N. Mex. Sponsors, IEEE Antennas and Propagation Society, USNC/URSI Commissions, Permanent NEM Committee. (K. F. Casey, The Dikewood Corp., 1613 University Boulevard, N.E., Albuquerque, NM 87102.)

May 25–28 **Symposium on the Composition of Nonurban Troposphere,** Williamsburg, VA. Sponsors, AMS, NASA, AGU. (Jack

Fishman, Mail Stop 401-B, NASA Langley Research Center, Hampton, VA 23665.)

May 26–28 16th Annual Congress and Annual General Meeting of the Canadian Meteorological and Oceanographic Society, Ottawa, Ontario, Canada (G. Isaac, Cloud Physics Research Division, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 Canada.)

May 31–June 4 **AGU Spring Meeting**, Philadelphia, Pa. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

June 7–9 Fourth Canadian Symposium on Mining Surveying and Deformation Measurements, Banff, Alberta, Canada. Sponsors, Shelloch Canada, Surveying Engineering, University of Calgary. (F. B. Climdgo, D. R. Pitoau and Associates Ltd., Suite 300, 1615 10th Avenue S.W., Calgary, Alberta, Canada T3C 0J7.)

June 13–17 International Symposium on Hydrometeorology, Denver, Colo. Sponsor, American Water Resources Association. (A. I. Johnson, Woodward-Clyde Consultants, 2909 West 7th Ave., Denver, CO 80204.)

June 14–17 45th Annual Meeting of the American Society of Limnology and Oceanography, Raleigh, N.C. (W. Baumeister, Business Manager, ASLO, 1530 12th Avenue, Grafton, WI 53024.)

June 15–18 **International Conference on Rainwater Cistern Systems**, Honolulu, Hawaii. Sponsors, University of Hawaii's Water Resources Research Center, AGU. (Yu-Si Fok, General Conference Chairman, Water Resources Research Center, Univ. of Hawaii, 2540 Dole Street, Honolulu, HI 96822.)

June 20–25 63rd Annual Meeting of the American Association for the Advancement of Science, Pacific Division, Santa Barbara, Calif. Sponsors, American Meteorological Society, Atmospheric and Hydrospheric Sciences Section of AAAS. Pacific Division (A. E. Leviton, Executive Director, AAAS (Pacific Division), California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118.)

June 21–25 11th International Laser Radar Conference, Madison, Wis. Sponsor, Space Science and Engineering Center of the University of Wisconsin (J. Edwards, Conference Coordinator, 11th International Laser Radar Conference, Space Science and Engineering Center, 1225 West Dayton Street, Madison, WI 53706.)

June 27–30 Western Conference on Water and Energy: Technical and Policy Issues, Fort Collins, Colo. Sponsors, ASCE, League of Women Voters, Council of State Governments. (D. Marchett, Stone and Webster Engineering Corp., P.O. Box 5406, Denver, CO 80217.)

June 27–July 2 Fifth International Conference on Geochronology, Cosmochronology, and Isotope Geology, Nikko National Park, Japan (K. Shibata, Geological Survey of Japan, Higashi 1-1-3, Yatabe, Ibaraki 305 Japan.)

July 14–16 National Conference on Environmental Engineering, Minneapolis, Minn. Sponsors, American Society of Civil Engineers (Environmental Engineering Division), University of Minnesota Department of Civil and Mineral Engineering, Minnesota Pollution Control Agency, Central States Water Pollution Control Association, Minnesota section of ASCE. (W. K. Johnson, Conference Chairman, Metropolitan Waste Control Commission, 350 Metro Square Building, St. Paul, MN 55101.)

July 19–30 International Association of Hydrological Sciences General Assembly, Exeter, United Kingdom (D. E. Walling, Chairman, Local Organizing Committee, Department of Geography, University of Exeter, Amory Building, Exeter EX4 4RJ, UK.)

July 27–30 Ninth International Symposium on Urban Hydrology, Hydraulics, and Sediment Control, Lexington, Ky. Sponsors, University of Kentucky's College of Engineering, Office of Continuing Education, Water Resources Institute. (H. J. Sterling, Department of Civil Engineering, 208A Anderson Hall, University of Kentucky, Lexington, KY 40506-0046.)

Aug. 2–6 Sixth International Symposium on the Physics and Chemistry of Ice, Rolla, Mo. Sponsors, American Physical Society, American Chemical Society, American Meteorological Society, International Commission on Snow and Ice of the International Union of Geologists and Geophysicists (P. L. Plummer, Graduate Center for Cloud Physics Research, 109 Norwood Hall, University of Missouri, Rolla, MO 65401.)

Aug. 2–13 Joint Oceanographic Assembly, Halifax, Nova Scotia, Canada. Sponsor, Scientific Committee on Oceanic Research. (Loo O'Quinn, National Steering Committee for JOA, c/o Canadian Committee on Oceanography, 240 Sparks St., Ottawa, Ontario K1A 0E6 Canada.)

Aug. 2–8 Second International Symposium/Workshop on Solar-Terrestrial Influences on Weather and Climate, Boulder, Colo. Sponsor, Lockheed Palo Alto Research Laboratory (Billy M. McCormac, Lockheed Palo Alto Research Laboratory, Dept. 52-12/B202, 3251 Hanover Street, Palo Alto, CA 94304.)

Aug. 8–13 Penrose Conference on Origin of Fluids and Metals in Porphyry and Epithermal Mineral Deposits, Dillon, Colo. Sponsor, GSA. (J. LeAnderson, Department of Geological Engineering, Colorado School of Mines, Golden, CO 80401.)

Aug. 15–20 Penrose Conference on Models of Diagenesis in Clastic Reservoirs, Kailua, Kona, Hawaii. Sponsor, GSA (J. R. Wood, COFRC, P.O. Box 446, La Habra, CA 90631.)

Aug. 15–21 Fourth International Symposium on Antarctic Earth Sciences, Ingle Farm, South Australia, Australia. Sponsors, Australian Academy of Science, Australian Academy of Technological Sciences, International Union of Geological Sciences, Scientific Committee on Antarctic Research, Geological Society of Australia, Inc., Univ. of Adelaide. (J. B. Jago, South Australian Institute of Technology, P.O. Box 1, Ingle Farm, South Australia, Australia 5098.)

Aug. 16–22 International Meeting on Generation of Major Basalt Types, Reykjavik, Iceland. Sponsors, IAVCEI, IAGC. (Basalt Meeting, c/o G. E. Sigvaldason, Nordic Volcanological Institute, 101 Reykjavik, Iceland.)

Aug. 15–22 IAVCEI and IAGC Joint Meeting, Reykjavik, Iceland. (G. E. Sigvaldason, Nordic Volcanological Institute, Univ. of Iceland, Geosciences Building, 101 Reykjavik, Iceland.)

Aug. 16–18 International Conference on Coal-Fired Power Plants and the Aquatic Environment, Copenhagen, Denmark. Sponsors, International Association on Water Pollution Research, the International Union of Pure and Applied Chemistry, Nordic Cooperative Organization for Applied Research. (Dis Congress Service, Linde Alle 48, DK-2720 Copenhagen, Denmark.)

Aug. 22–28 11th International Congress on Sedimentology, Hamilton, Ontario, Canada. Sponsor, IAS. (IAS Congress 1982, Department of Geology, McMaster University, Hamilton, Ontario L8S 4M1, Canada.)

Aug. 22–28 **Third Circum-Pacific Energy and Mineral Resources Conference**, Honolulu, Hawaii. Sponsor, IUGS. (AAPG Convention Department, P.O. Box 979, Tulsa, OK 74101.)

Aug. 23–27 Second Symposium on Applied Glaciology, Hanover, N.H. Sponsor, International Glaciological Society. (Secretary General, International Glaciological Society, Lensfield Road, Cambridge CB2 1ER, United Kingdom.)

Aug. 23–27 Ninth Annual Meeting of the European Geophysical Society, in conjunction with the 18th General Assembly of the European Seismological Commission, Leeds, United Kingdom. (J. C. Briden, Department of Earth Sciences, University of Leeds, Leeds LS2 9JT, England.)

Aug. 25–27 23rd U.S. Symposium on Rock Mechanics, Berkeley, Calif. Sponsors, U.S. National Committee for Rock Mechanics, International Society for Rock Mechanics, University of California. (Organizing Committee, 23rd Rock Mechanics Symposium, c/o Richard E. Goodman, Department of Civil Engineering, 440 Davis Hall, University of California, Berkeley, CA 94720.)

August 28–31 Alfred-Wegener-Conference on Geophysical, Geochemical and Petrological Evidence on Deformation and Composition of the Continental Subcrustal Lithosphere, Beeheim, Federal Republic of Germany. (K. Fuchs, Geophysical Institute University, Hertzstr. 16, D-7500 Karlsruhe, Federal Republic of Germany.)

Aug. 31–Sept. 2 International Conference on the Planar and Linear Fabrics of Deformed Rocks, Zurich, Switzerland. Sponsor, Tectonic Studies Group, ETH. (J. G. Ramsay, Geologisches Institut, ETH-Zentrum, CH-8092 Zurich, Switzerland.)

Sept. 3–11 Fourth World Congress on Water Resources, Buenos Aires, Argentina. Sponsor, International Water Resources Association. (G. E. Stout, President of the U.S. Geographical Committee, Water Resources Center, University of Illinois, 2535 Hydrosystems Laboratory, 208 N. Romine, Urbana, IL 61801.)

Sept. 13–16 45th Annual Meeting of the Meteoritical Society, St. Louis, Mo. (G. Crozaz, Washington University, Box 1105, St. Louis, MO 63130.)

Sept. 20–22 Oceans '82 Conference and Exhibition, Washington, D.C. Sponsors, Marine Technology Society, Institute of Electrical and Electronics Engineers Council on Oceanic Engineering. (Oceans '82 Technical Program Chairman, 1730 M Street, N.W., Suite 412, Washington, D.C. 20036.)

Sept. Third International Kimberlite Conference, Clermont-Ferrand, France. (Francoise Boudier, Université de Nantes, Laboratoire de Tectonophysique, 2 Rue de la Houssinière, 44072 Nantes, France.)

May or Sept. Scientific Meeting of IAPSO, Halifax, Canada. (E. C. LaFond, LaFond Oceanic Consultants, P.O. Box 7325, San Diego, CA 92107.)

Oct. 4–9 International Symposium on Polders of the World, Agora, Lelystad, The Netherlands. Sponsors, Department of Civil Engineering of the Delft University of Technology, Commission on Hydrological Research of the Netherlands Organization of Applied Scientific Research, the Ijsselmeerpolders Development Authority, Society for Waterworks and Land Use Planning. (I. H. Wijkel, Information Centre 'New Land,' Oostvaardersdijk 01-13, 8242 PA Lelystad, the Netherlands.)

Oct. 18–21 GSA Annual Meeting, New Orleans, La. (J. M. Latulippe, Meetings Department, GSA, P.O. Box 9140, Boulder, CO 80301.)

Dec. 6–10 **AGU Fall Meeting**, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

1983

Feb. 1–11 15th Pacific Science Congress, Dunedin, New Zealand. Sponsor, University of Otago. (Secretary-General, P.O. Box 6063, Dunedin, New Zealand.)

June 13–15 **International Symposium on Gas Transfer at Water Surfaces**, Ithaca, N.Y. Sponsors, Cornell University, AGU. (W. H. Brutsaert or G. H. Jirka, School of Civil and Environmental Engineering, Cornell University, Hollister Hall, Ithaca, NY 14853.)

July 18–23 Fourth International Conference on Permafrost, Fairbanks, Alaska. Sponsors, National Academy of Sciences, State of Alaska. (L. De Goes, Polar Research Board, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington, DC 20418.)

Aug. 15–26 18th General Assembly of IUGG, Hamburg, Federal Republic of Germany. (P. Melchior, Observatoire Royal de Belgique, Avenue Circulaire 3, B-1180 Bruxelles, Belgium.)

Aug. 27 Symposium Commemorating the 100th Anniversary of the Mount Krakatau Eruption, Jakarta, Indonesia. Sponsor, Indonesian Institute of Sciences. (Didin Sastrapradja, Deputy Chairman for Natural Sciences, LIPI JL, Teuku Chik Ditiro 43, Jakarta, Indonesia.)

Sept. 12–14 National Water Well Association 35th Annual Convention and Exposition, St. Louis, Mo. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.)

Oct. 31–Nov. 3 GSA Annual Meeting, Indianapolis, Ind. (J. M. Latulippe, Meetings Department, GSA, P.O. Box 9140, Boulder, CO 80301.)

Dec. 5–9 **AGU Fall Meeting**, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

1984

July 21–28 Eighth World Conference on Earthquake Engineering, San Francisco, Calif. Sponsor, Earthquake Engineering Research Institute. (R. B. Matthiesen, Chair-8WCEE, EERI, 2620 Telegraph Avenue, Berkeley, CA 94704.)

FUTURE AGU MEETINGS

Fall Meetings
December 6–10, 1982, San Francisco
December 5–9, 1983, San Francisco

Spring Meetings
May 31–June 4, 1982, Philadelphia

AAPG American Association of Petroleum Geologists
AMS American Meteorological Society
ASCE American Society of Civil Engineers
GSA Geological Society of America
IAG International Association of Geodesy
IAGA International Association of Geomagnetism and Aeronomy
IAHS International Association for Hydrological Sciences
IAMAP International Association of Meteorology and Atmospheric Physics
IAPSO International Association of Physical Sciences of the Ocean
IASPEI International Association of Seismology and Physics of the Earth's Interior
IAVCEI International Association of Volcanology and Chemistry of the Earth's Interior
IUGS International Union of Geological Sciences
IWRA International Water Resources Association
MSA Mineralogical Society of America
SEG Society of Exploration Geophysicists
SEPM Society of Economic Paleontologists and Mineralogists
URSI International Union of Radio Science

GAP

Separates

High-quality reprints of individual articles from AGU journals are available in limited quantities. The separates program is designed to provide you with single articles for your personal use. Small quantity purchases for classroom use or library reserve copies for classes are available while supplies last; send your request on department stationery giving the class title and number of enrolled students. Quantity orders for resale or redistribution will not be filled.

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU.

Cost: $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order.

Deposit Account: A minimum of $10.00 may be placed on deposit with AGU for the purchase of separates. If funds are on deposit, the cost of the first article is only $2.00 and $1.00 for each additional article in the same order.

Separates will be mailed within 3 weeks of journal publication or within 10 days if ordered after the journal has appeared. Separates are available for purchase for two years from date of publication.

Copies of English translations of articles from Russian translation journals are available either in unedited form at the time of their listing in EOS or in final printed form when a journal is published. The charge is $2.00 per Russian page.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

Meteorology

3710 Boundary layer structures and processes
TRANSIENT RADIATIVE INFLUENCES OF CUMULUS CLOUDS ON SURFACE TEMPERATURE AND FLUXES
S. G. Bradley (Division of Cloud Physics, CSIRO, Sydney, Australia)

Diurnal or static solutions are usually considered for radiative forcing of surface temperature. In this paper short-time solutions, applicable to radiative transients caused by cloud motion, are described for both land and ocean surfaces. The short-time approximation predicts surface temperature changes independent of sensible and latent heat fluxes. The theory suggests the ocean skin temperature will have a response shorter than 10 s and so will follow changes in downward long-wave flux.

The theory is supported by results from airborne remote radiation measurements beneath clouds. Over the land deduced thermal inertia values agree closely with those predicted from geological data. Oceanic observations allow a viscous layer thickness to be estimated which is in agreement with previous direct findings. Measured temperature excursions demonstrate that cloud-related radiative forcing is significant and should be considered in boundary layer models which incorporate clouds. (Cloud shadows, surface temperature, thermal inertia, ocean viscous layer.)
J. Geophys. Res., Green, Paper 1C1734

3710 Boundary layer structures and processes
MODIFICATION OF KONDO'S FORMULAS ON THE BULK TRANSFER COEFFICIENTS OF TURBULENT FLUXES OVER THE OCEAN
N. Yasuda (Geophysical Institute, Faculty of Science, Tohoku University, Sendai 980, Japan)

A bulk method is most suitable to the estimation of turbulent fluxes over the wide area of ocean because the fluxes are estimated only with the usual meteorological data, that is, the wind speed, the air temperature, the humidity and the sea surface temperature and the accuracy of the bulk method have been recently advanced. Particularly, a method presented by Kondo (Boundary-Layer Meteor., Vol.9, 91-112, 1975) is very excellent and was used by many researchers. In the present work, the formulas of the bulk transfer coefficients for the momentum, sensible heat and vapor fluxes presented by him are reformed in order to explicitly express the essence of the theory and in order to be easily applied in the various problems in the atmospheric boundary layer including the estimation of turbulent fluxes in the conditions in which the thermal stratification is non-neutral and the observation heights of wind speed, air temperature and humidity are different from each other. The relative differences between the values of the bulk transfer coefficients by the reformed formulas and the values by the original Kondo's formulas are very small. (Bulk transfer coefficients, turbulent fluxes)
Sci. Rep. Tohoku Univ., Ser. 5 (Tohoku Geophys. Journ.), Vol.28, No.3, 1981.

3710 Boundary layer structures and processes
SURFACE WIND ANALYSES FOR SEASAT
R. A. Brown (Dept. of Atmospheric Sciences, AK-40, University of Washington, Seattle, WA 98195)
V. J. Cardone, T. Guymer, J. Hawkins,
J. E. Overland, W. J. Pierson, S. Peteherych,
J. C. Wilkerson, P. M. Woiceshyn, M. Wurtele

To establish SEASAT sensor wind measuring capabilities, the best possible surface winds were needed. Fortunately, during the 99 days of SEASAT operation, two large scale experiments were conducted. The first, the Gulf of Alaska Experiment (GOASEX), was directed at obtaining data in conjunction with SEASAT. The second, the Joint Air Sea Interaction Experiment (JASIN) was an independent and much more comprehensive air and sea investigation, and fortunately provided excellent comparison data for SEASAT. In addition, several storms provided good qualitative comparison windfields. Since the windfields have been developed independently of satellite determined winds, this paper deals only with the surface wind analysis and its accuracy. A subsequent paper will use these results to discuss the satellite sensor predictions compared to these data sets.
J. Geophys. Res., Green, Paper 1C1718

3715 Chemical composition and chemical interactions
NO_x IN THE MID-PACIFIC TROPOSPHERE
J. F. Noxon (Fritz Peak Observatory, Aeronomy Laboratory, NOAA/ERL, Boulder, CO 80303)

Measurements of NO_2 in spectra of the rising and setting sun from Mauna Loa, Hawaii, gave a mean of 30 ppt for NO_x at 3 km altitude in the mid-Pacific troposphere. Natural variations of about 50 percent occurred about this mean together with the systematic nocturnal decay expected from the reaction of NO_2 with ozone. The tropospheric column abundance of NO_2 exhibited a correlation with the variation of NO_2 density at 3 km; the changes in both appear related to the strength of the trade winds and may reflect an overall rising or sinking motion in the lower troposphere. The measured NO_x appears to be free of any anthropogenic influence and low enough in density that in the lower mid-Pacific troposphere the source of ozone is downward diffusion from above and not local photochemical production.
Geophys. Res. Lett., Paper 1L1710

Particles and Fields—Interplanetary Space

5340 Shock waves
TEST PARTICLE STUDY OF LANDAU DAMPING OF STEEPENING MAGNETOSONIC WAVES
H. Matsumoto (Radio Atmospheric Science Center, Kyoto University, Uji, Kyoto 611, Japan), A. Barnes

A test particle study of Landau damping of steepening large-amplitude magnetosonic waves is carried out. Motions of test particles in a model steepening large-amplitude magnetosonic wave are traced. The kinetic energy change of the ensemble of test particles is computed to estimate an effective Landau damping rate of the magnetosonic wave. The numerical results are compared with the linear kinetic theory of Landau damping and interpreted in terms of a simple physical picture for particle trapping. (Magnetosonic waves, Shock, Steepening, Landau damping).
J. Geophys. Res., Blue, Paper 1A1741

Particles and Fields—Ionosphere

5505 Airglow
SPECTROSCOPY OF THE EXTREME ULTRAVIOLET DAYGLOW DURING ACTIVE SOLAR CONDITIONS
E. P. Gentieu (NASA/Goddard Space Flight Center, Greenbelt, Maryland, 20771), P. D. Feldman, R. W. Eastes, and A. B. Christensen

Extreme ultraviolet spectra of the daytime airglow in the range 530 to 1500 Å were obtained at 3.5 Å resolution from a rocket experiment launched 27 June 1980 from WSMR. The launch occurred near the period of peak solar cycle 21 activity. A limb viewing geometry was utilized to enhance emissions originating from a molecular nitrogen source. Much of the previously observed apparent continuum emission between 800 and 1200 Å is from NI and OI. A number of weak transitions from molecular nitrogen singlet states have also been identified. A comparison of the observed changes in intensity in several NI and OI emissions between 9 January 1978 and 27 June 1980 indicates that at 220 km: (1) the atomic nitrogen density has increased in excess of a factor of three; (2) the solar EUV flux for $\lambda < 555$ Å has doubled whereas the integrated photoelectron flux between 10 and 50 eV has remained unchanged. (Airglow, extreme ultraviolet spectra).
Geophys. Res. Lett., Paper 1L1622

5510 Airglow
RADAR AURORAL OBSERVATIONS DURING A BURST OF IRREGULAR MAGNETIC PULSATIONS
C.I. Haldoupis (Max-Planck-Institut für Aeronomie, 3411 Katlenburg-Lindau 3, F.R.G.), E. Nielsen, J.A. Holtet, A. Egeland, H.A. Chivers.

Micropulsations data from an auroral station are compared with concurrent STARE radar observations from the E-region above the station during a substorm event. The substorm onset is marked by a strong burst of irregular pulsations (Pi2) accompanied by abrupt intensifications in the equivalent current, the backscatter intensity, and the riometer absorption. The magnetic Px and Py pulsation components have a reasonable degree of correlation and the polarization properties of the horizontal disturbance vector exhibits well defined changes during the first few minutes after onset. The radio signal undergoes deep quasiperiodic fading which is closely related to simultaneous Pi2 amplitude variations. The radar Doppler data, which show normal fluctuations in the electron drift velocity, exclude modulation of radio backscatter by directional variations of the electric field. It is argued that the Pi2 pulsations and the variations seen in the backscatter are reflecting changes of the ionospheric currents due to conductivity modifications dictated by variations in the field-aligned currents flowing in the region. The possibility exists that the Pi2 is closely related to precipitation pulsations as reported by Heacock and Hunsucker (1977). (Electric fields, magnetic pulsations, particle precipitation).
J. Geophys. Res., Blue, Paper 1A1586

5515 Auroras
INVERTED V'S AND/OR DISCRETE ARCS: A THREE-DIMENSIONAL PHENOMENON AT BOUNDARIES BETWEEN MAGNETIC FLUX TUBES
G. Atkinson (Herzberg Institute of Astrophysics, National Research Council, 100 Sussex Drive, Ottawa, Ontario K1A 0R6)

If discrete arcs and inverted V's are associated with current sheets and the U-shaped electric potential structure, then existing two-dimensional models are probably inadequate. [illegible]
J. Geophys. Res., Blue, Paper 1A1666

5530 Electric fields
CHATANIKA RADAR OBSERVATIONS OF THE ELECTROSTATIC POTENTIAL DISTRIBUTION OF AN AURORAL ARC
O. de la Beaujardière (SRI International, Menlo Park, California, 94025) R. Vondrak [illegible]

[illegible]
J. Geophys. Res., Blue, Paper 1A1507

5530 High-latitude ionospheric currents
MODELING OF HIGH LATITUDE CURRENTS IN A SUBSTORM
J. L. Karty (Department of Space Physics and Astronomy, Rice University, Houston, Texas, 77001), C.-K. Chen, R. A. Wolf, M. Harel, R. W. Spiro

[illegible]
J. Geophys. Res., Blue, Paper 1A1701

5530 High Latitude Ionospheric Currents
ELECTRODYNAMIC PROPERTIES OF THE EVENING SECTOR IONOSPHERE WITHIN THE REGION-2 FIELD-ALIGNED CURRENT SHEET
R. M. Robinson (Radio Physics Laboratory, SRI International, Menlo Park, CA 94025), R. R. Vondrak and T. A. Potemra

[illegible]
J. Geophys. Res., Blue, Paper 1A1630

5535 Interactions between waves and particles
[illegible]
J. Geophys. Res., Blue, Paper [illegible]

5540 Wave propagation
[illegible]
J. Geophys. Res., Blue, Paper [illegible]

5540 Ion densities and temperatures
OBSERVATIONS OF THE DIURNAL DEPENDENCE OF THE HIGH-LATITUDE F-REGION ION DENSITY BY DMSP SATELLITES
J.J. Sojka (Center for Atmospheric and Space Sciences, Utah State University, Logan, Utah 84322), W.J. Raitt, R.W. Schunk, F.J. Rich and R.C. Sagalyn

Data from the DMSP-F2 and F4 satellites for the period December 5-10, 1979 have been used to study the diurnal dependence of the high-latitude ion density at 800 km altitude. [illegible]
J. Geophys. Res., Blue, Paper 1A1729

[illegible] qualitative agreement with the diurnal dependence predicted by a theoretical model of the ionospheric density at high latitudes under conditions of low convection speeds.
J. Geophys. Res., Blue, Paper [illegible]

[illegible]

Particles and Fields—Magnetosphere

5705 Bow shock waves
CHARACTERISTICS OF THE ELF WAVES ASSOCIATED WITH UPSTREAM ION BEAMS
M.M. Hoppe (Institute of Geophysics, University of California, Los Angeles, CA 90024), C.T. Russell, T.E. Eastman and L.A. Frank

This report describes a new class of upstream wave with relatively high frequencies [illegible] appears to be a necessary condition for the observation of the waves. Beam presence is however not a sufficient condition for existence of the

International Geophysical Calendar for 1982

(See other side for information on use of this Calendar)

	S	M	T	W	T	F	S	S	M	T	W	T	F	S	
						1	2	27	28	29	30	1	2	3	
	[3	[4	5	6	7	8	9	4	5	6	7	8	9	10	
	10	11	12	13	14	15	16	11	12	13	14	15	16	17	JULY
JANUARY	17	18	19	20	21	22	23	18	19	20	21	22	23	24	
	24	25	26	27	28	29	30	25	26]	[27]	[28]	[29]	[30]	31]	
	31	1	2	3	4	5	6	1	2	3	4	5	6	7	
	7	8	9	10	11	12	13	8	9	10	[11	[12	[13	[14	
FEBRUARY	14	15	16	17	18	19	20	[15	16	17	18	19	20	21	AUGUST
	21	22	23	24	25	26	27	22	23	24	25	26	27	28	
	28	1	2	3	4	5	6	29	30	31	1	2	3	4	
	7	8	9	10	11	12	13	5	6	7	8	9	10	11	
MARCH	14	15	16	17	18	19	20	12	13	14	15	16	17	18	SEPTEMBER
	21	22	23	24	25	26	27	19	20	21	22	23	24	25	
	28	29	30	31	1	2	3	26	27	28	29	30	1	2	
	4	5	6	7	8	9	10	3	4	5	6	7	8	9	
APRIL	11	12	13	14	15	16	17	10	11	12	13	14	15	16	
	18	19	20	21	22	[23	24	17	18	19	20	21	[22]	[23]	OCTOBER
	25	26	27	28	29	30	1	24	25	26	27	28	29	30	
	2	[3]	[4]	[5]	[6]	7	8	31	1	[2]	[3]	4	5	6	
	9	10	11	12	13	14	15	7	8	9	10	11	12	13	
MAY	16	17	18	19	20	21	22	14	15	16	17	18	19	20	NOVEMBER
	23	24	25	26	27	28	29	21	22	23	24	25	26	27	
	30	31	1	2	3	4	5	28	29	30	1	2	3	4	
	6	7	[8]	[9]	[10]	[11]	[12]	5]	6]	7	8	9	10	11	
JUNE	13	14	15	16	17	18	19	12	[13]	14	15	16	17	18	DECEMBER
	20	21	22	[23]	[24]	25	26	19	20	21	[22	[23	24	25	
	27	28	29	30	1	2	3	26	27	28	29	30	31	1	
	S	M	T	W	T	F	S	2	[3	[4	5	6	7	8	
								9	10	11	12	13	14	15	1983
								16	17	18	19	20	21	22	JANUARY
								23	24	25	26	27	28	29	
								30	31						
								S	M	T	W	T	F	S	

13 Regular World Day (RWD)
14 Priority Regular World Day (PRWD)
18 Quarterly World Day (QWD) also a PRWD and RWD
2 Regular Geophysical Day (RGD)
9 10 World Geophysical Interval (WGI)
[3 Day with unusual meteor shower activity, Northern Hemisphere
5] Day with unusual meteor shower activity, Southern Hemisphere
25 Day of Solar Eclipse
14 15 Airglow and Aurora Period
20* Dark Moon Geophysical Day (DMGD)
20+ Incoherent Scatter Coordinated Observation Day and Coordinated Tidal Observation Day

NOTES:

1. An Alpine Experiment (ALPEX), of the WMO/ICSU World Climate Research Program, continues from 1 January 1982 through 30 September 1982.

2. Post-SMY STIP INTERVAL XIII (started 1 December 1981) runs through 31 January 1982; and STIP INTERVAL XIV is 20 May through 20 July 1982.

3. Middle Atmosphere Program (MAP) begins 1 January 1982 and runs through 1985.

OPERATIONAL EDITION, September 1981

(see other side)

EXPLANATIONS

This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observations which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to World Data Centers (WDCs) in many instances emphasize Calendar days. The Calendar is prepared by the International Ursigram and World Days Service (IUWDS) with the advice of spokesmen for the various scientific disciplines. For greater detail concerning explanations or recommendations your attention is called to information published periodically in IAGA News, IUGG Chronicle, URSI Information Bulletin or other scientific journals.

The definitions of the designated days remain as described on previous Calendars. Universal Time (UT) is the standard time for all world days. Regular Geophysical Days (RGD) are each Wednesday. Regular World Days (RWD) are three consecutive days each month, always Tuesday, Wednesday and Thursday near the middle of the month. Priority Regular World Days (PRWD) are the RWD which fall on Wednesdays. Quarterly World Days (QWD) are one day each quarter and are the PRWD which fall in the World Geophysical Intervals (WGI). The WGI are fourteen consecutive days in each season, beginning on Monday of the selected month, and normally shift from year to year. In 1982 the WGI will be February, May, August and November.

The Solar Eclipses are January 25 (partial) beginning in South Atlantic Ocean skirting the Antarctic continent, crossing the Antarctic peninsula and ending in South Pacific Ocean south of New Zealand, June 21 (partial) beginning in South Atlantic Ocean, passing south of Africa and ending in Indian Ocean; July 20 (partial) beginning over Kamchatka peninsula, crossing Siberia, southern Finland, Denmark and ending in Portugal; and December 15 (partial) beginning west of Portugal in Atlantic Ocean, crossing England, Norway, Sweden, Finland, USSR, and ending in China north of Pakistan.

Meteor Showers (selected by P. M. Millman, Ottawa) include important visual showers and also unusual showers observable mainly by radio and radar techniques. The dates are coded to indicate whether the shower is observable in the northern or southern hemisphere.

The occurrence of unusual solar or geophysical conditions is announced or forecast by the IUWDS through various types of geophysical "Alerts" which are widely distributed by telegram and radio broadcast on a current schedule. Stratospheric warmings (STRATWARM) are also designated. The meteorological telecommunications network coordinated by WMO carries these worldwide Alerts once daily soon after 0400 UT. For definitions of Alerts see IUWDS "Synoptic Codes for Solar and Geophysical Data, Third Revised Edition 1973" and its amendments. Retrospective World Intervals are selected and announced by MONSEE and elsewhere to provide additional analyzed data for particular events studied in the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) programs.

RECOMMENDED SCIENTIFIC PROGRAMS
OPERATIONAL EDITION

(The following material was reviewed in 1981 by spokesmen of IAGA, WMO and URSI as suitable for coordinated geophysical programs in 1982.)

Airglow and Aurora Phenomena. Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanism of, *inter alia*, low latitude aurora, the coordinated use of all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately two weeks' duration centered on the New Moon are proposed for high resolution studies of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter.

Atmospheric Electricity. Not-continuous measurements and data reduction for continuous measurements of atmospheric electric current density, field, conductivities, space charges, ion number densities, ionosphere potentials, condensation nuclei, etc.; both at ground as well as with radiosondes, aircraft, rockets; should be done with first priority on the RGD each Wednesday, beginning on 6 January 1982 at 1800 UT, 13 January at 0000 UT, 20 January at 0600 UT, 27 January at 1200 UT, etc (beginning hour shift six hours each week, but is always on Wednesday). Minimum program is at the same time on PRWD beginning with 20 January at 0600 UT. Data reduction for continuous measurements should be extended, if possible, to cover at least the full RGD including, in addition, at least 5 hours prior to indicated beginning time. Measurements prohibited by bad weather should be done 24 hours later. Results on sferics and ELF are wanted with first priority for the same hours, short-period measurements centered around the minutes 35-50 of the hours indicated. Priority Weeks are the weeks which contain a PRWD; minimum priority weeks are the ones with a QWD. The World Data Centre for Atmospheric Electricity, 7 Karbysheva, Leningrad 194018, USSR, is the collection point for data and information on measurements.

Geomagnetic Phenomena. It has always been a leading principle for geomagnetic observatories that operations should be as continuous as possible and the great majority of stations undertake the same program without regard to the Calendar.

Stations equipped for making magnetic observations, but which cannot carry out such observations and reductions on a continuous schedule are encouraged to carry out such work at least on RWD (and during times of MAGSTORM Alert).

Ionospheric Phenomena. Special attention is continuing on particular events which cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is possible to analyze the detailed data only for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the vertical incidence (VI) sounding program, the summary recommendations are: (a) all stations should make soundings at least every quarter hour. Stations which normally record at every quarter should, if possible, record more frequently on RWDs; (b) all stations are encouraged to make f-plots on RWDs; f-plots should be made for high latitude stations, and for the so-called "representative" stations at lower latitudes for all days (i.e., including RWDs and WGIs). (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate and low latitude stations); (c) copies of hourly ionograms with appropriate scales for QWDs are to be sent to WDCs; (d) stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under Airglow and Aurora Phenomena.

For incoherent scatter observation program, every effort should be made to obtain measurements at least on the Incoherent Scatter Coordinated Observation Days, and intensive series should be attempted whenever possible in WGIs or the Airglow and Aurora Periods. The need for collateral VI observations with not more than quarter-hourly spacing at least during all observation periods is stressed. Dr. M.J. Baron (U.S.A.), URSI Working Group G.5, is coordinating special programs.

For the ionospheric drift or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including RWDs.

For traveling ionosphere disturbances propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected PRWD and RWD.

For the ionospheric absorption program half-hourly observations are made at least on all RWDs and half-hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally high or abnormally low absorption (approximately October-March, Northern Hemisphere; April-September, Southern Hemisphere).

For back-scatter and forward-scatter programs, observations should be made and analyzed on all RWDs at least.

For synoptic observations of mesospheric (D region) electron densities, several groups have agreed on using the RGD for the hours around noon.

For ELF noise measurements involving the earth-ionosphere cavity resonances any special effort should be concentrated during the WGIs.

It is recommended that more intensive observations in all programs be considered on days of unusual meteor activity.

Meteorology. Particular efforts should be made to carry out an intensified program on the RGD — each Wednesday, UT. A desirable goal would be the scheduling of meteorological rocketsondes, ozone sondes and radiometer sondes on these days, together with maximum-altitude rawinsonde ascents at both 0000 and 1200 UT.

During WGI and STRATWARM Alert Intervals, intensified programs are also desirable, preferably by the implementation of RGD-type programs (see above) on Mondays and Fridays, as well as on Wednesdays.

Middle Atmosphere Program (MAP). MAP runs from 1 January 1982 through 1985. Techniques for observing the middle atmosphere should concentrate or center their observations on the RGDs, PRWDs, and QWDs. It is recommended that observing runs for studies of planetary waves and tides be at least 10 days centered on the PRWDs and QWDs. Non-continuous studies of stratospheric warmings and the effects of geomagnetic activity on the middle atmosphere must be initiated by STRATWARM and MAGSTORM alerts, respectively. For more details see the "Recommended Scientific Programs" on the reverse of the Middle Atmosphere Dynamics Calendar for 1982, which will be published as a special edition of the IGC for 1982.

Solar Phenomena. Observatories making specialized studies of solar phenomena, particularly using new or complex techniques, such that continuous observation or reporting is impractical, are requested to make special efforts to provide to WDCs data for solar eclipse days, RWDs and during PROTON/FLARE ALERTS. The attention of those recording solar noise spectra, solar magnetic fields and doing specialized optical studies is particularly drawn to this recommendation.

Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy. Experimenters should take into account that observational effort in other disciplines tends to be intensified on the days marked on the Calendar, and schedule balloon and rocket experiments accordingly if there are no other geophysical reasons for choice. In particular it is desirable to make rocket measurements of ionospheric characteristics on the same day at as many locations as possible; where feasible, experimenters should endeavor to launch rockets to monitor at least normal conditions on the Quarterly World Days (QWD) or on RWDs, since these are also days when there will be maximum support from ground observations. Also, special efforts should be made to assure recording of telemetry on QWD and Airglow and Aurora Periods of experiments on satellites and of experiments on spacecraft in orbit around the Sun.

For URSI/IAGA Coordinated Tidal Observations Program (CTOP) contact Dr. R. G. Roper (USA) for the 1982 calendar.

The International Ursigram and World Days Service (IUWDS) is a permanent scientific service of the International Union of Radio Science (URSI), with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. IUWDS adheres to the Federation of Astronomical and Geophysical Services of the International Council of Scientific Unions. The IUWDS coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 1982 has been drawn up by J. V. Lincoln, of the IUWDS Steering Committee, in close association with A. H. Shapley, Chairman of MONSEE of SCOSTEP, and spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI. Similar Calendars have been issued annually beginning with the IGY, 1957-58, and have been published in various widely available scientific publications.

Published for the International Council of Scientific Unions with the financial assistance of UNESCO.

Additional copies are available upon request to IUWDS Chairman, Dr. P. Simon, Urslgrammes Observatoire, 92190 Meudon, France, or IUWDS Acting Secretary for World Days, Miss H. E. Coffey, WDC-A for Solar-Terrestrial Physics, NOAA, D63, 325 Broadway, Boulder, Colorado 80303, U.S.A.

Planetology

Physical Properties of Rocks

Seismology

Solar Physics, Astrophysics, and Astronomy